PUBLISHED PAPERS AND ADDRESSES OF JOHN CAMPBELL MERRIAM

VOLUME IV

PUBLISHED BY THE CARNEGIE INSTITUTION OF WASHINGTON
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HISTORY

HISTORY AND EDUCATION

THE instrument called history, which brings the past to witness in forming our estimates of the future, comes vividly to mind when we see a graduating class go out on Washington's Birthday from the doors of a University in the Nation's Capital.

The fact that I do not know an educational institution of importance which fails to give history a prominent place in its curriculum might be taken to indicate that it is not necessary to emphasize the significance of this subject in education. And yet, with due credit for the great advances made in stating the case for history—even in institutions for higher education and research—I am convinced that in this field there is still open such an opportunity for new constructive effort as can scarcely be found elsewhere in the possible range for application of human intellect. I believe that the results of historical study and research, if given their real values as to fact and interpretation, may still make enormous contribution toward the solution of much in our economic, social, and political life that seems otherwise nearly insoluble. Especially desirable is the development of this phase of knowledge for the educational guidance of a people through whom the ballot has such an important part in determining the policy of government.

In order to define the place of history in education, may I indicate briefly an assumed outline of a program by which the student is prepared for the work expected of him by the community? No detailed plan of education can be prepared which will serve perfectly for more than one person. It is only in their broader outlines that one is justified in considering proposals which might be used for any large group.

One classification of the content of education indicates that it is inadequate if it does not prepare us for our particular places in life by giving, *first*, something concerning the world about us, in

Convocation address at George Washington University, February 22, 1924. *George Washington University Bulletin*, vol. 23, no. 1, pp. 3–12, March 1924.

which we live and work—the earth, the life upon it; *second*, an estimate of the real nature of human kind, with its modes of expression and action—in other words, to know ourselves; *third*, an understanding of the normal relations existing among the individuals in human society. Important as these three kinds of information are, they furnish us only the status of the world at a given moment, whereas we are concerned with it as an operating machine or organism. This means that we must see, *fourth*, the movement of the entire scheme—the universe, man, and society through time—which introduces change, sequence, or history. But this is not always mere change in the sense of succession. There may be growth, or progress, or creative expression, which is a *fifth* element of exceptional significance. Last of all, it is necessary for each individual to know his personal relation to the world in the sense of opportunity and adaptability relative to the scheme of a complicated universe of things physical and human—moving, changing, growing through time.

In all education there must be a large measure of the purely descriptive element relating to details which touch our practical day by day lives; but the most important functions concern principles and modes of operation, or laws, rather than descriptions. Some think that education tells us all about everything—I believe that it should rather tell us what everything is all about.

In our study of the physical world it is more important to understand the laws involved in the fundamental forces concerning interrelations between bodies than it is to know the form or location of any individual object at a given moment: gravitation, light, electricity, which seem applicable everywhere and bring unity into the world, are much more significant than the form of any rock or the height of any mountain at a particular time. Or, if you discuss the shape and size of a crystal, it is the laws of chemistry and physics relating to the fundamental nature of matter and the forces involved in it to which you must look for your explanation of what appears rather than to mere measuring of length, breadth, and height, and the counting of crystal faces.

The farther we go in the field of physical sciences the more impressive becomes the array of evidence indicating unity in operation of the natural world. In spite of the almost intuitive expectation that one might have of differences within the vastly spread

mist of stars through which the stellar universe reveals itself about us, the experience of the astronomer, physicist, and chemist makes it difficult for them to convince themselves that unity and continuity of physical law do not extend with almost unvarying uniformity to the uttermost realms we know.

With such evidence of unity in the so-called physical universe, one unconsciously looks for some coordinate expression in the living world—and here, in the course of long-continued inspection, there have appeared evidences of application of another kind of unity of principle—expressed in the laws of growth, which have translated themselves into laws of progress, which mean not merely development of the individual but advancement through modification of the living world in general.

So, inevitably, there must arise a question regarding the kind of approach which we should make to that great volume of material included in the data of history concerning human kind and its relation to the world about it. When we come to know man with thoroughness, how far shall we find that the modes of operation in his history have been such that we may classify them in terms of law? If we consider human life moving through time, shall we find the principle of growth—change—advance, expressing itself as in other living things the history of which has been subjected to careful scrutiny?

History has been described as having various functions. According to one view it furnishes the machinery by which we secure the facts or the truth concerning the past. This may be done with or without reference to the connectedness of the series of events. The significance might be large even if it concerned only the repetition of events without reference to the possibility of anything more than continued repetition. Perhaps the facts are not always necessary. It is sometimes considered immaterial whether George Washington did or did not cut down the cherry tree, so long as we are confident that he always told the truth.

Merely stated as facts, the materials of history sometimes have value as illustrations by analogy. According to this view the history of the Greeks, the Egyptians, or the dinosaurs might give illustration of certain possibilities in life processes without their necessarily having any relation to the life of to-day.

In general, history involves the elements of causal relation in

the succession of events leading to the present and preparing the way for the future. If we are concerned with investigation of an institution, such as the Constitution of the United States, it is essential that, with other facts, we learn the truth with reference to what it was intended to accomplish. So a second view of history represents a study of connected events or sequences, giving us the steps leading to the present and illustrating the method of accumulation and organization by which our institutions have originated. Social development is characterized by continuing addition to classified knowledge. Individuals disappear, but the body of available information and the consciousness of society persist. Discovery and research contribute by bringing in new data; science and learning organize it; business applies it; education carries it on from man to man or generation to generation. Thus we desire to have not merely the facts but with these the method of their growth.

A third view adds to analogy, to repetition, and to continuity in accumulation and organization, a study of the laws of growth through reorganization and creation of new conditions or states of being. This phase of history touches the evidence indicating that conditions are not merely changing, but are becoming different because of something in their nature which results in movement in a definite direction. In this method of approach we are concerned with the nature of the process of change and the laws determining the direction in which it moves, thus opening the way to a possible projection of the scheme into the future with suggestion as to what is yet to come.

As commonly interpreted, history is represented by a written record. This will almost inevitably present the evidence with considerable distortion due to the personal element, but the expression of the author's personal bias is itself often of value. The larger part of historical data must necessarily consist of description or narrative, to which there may be added an interpretation of the causes and effects. Sometimes records which are not written may actually convey more accurate information and with less chance of distortion than is true in the human description or opinion.

In recent years the interpretative aspect of history has developed rapidly. It is due, in considerable measure, to the more intimate

relation of nations and peoples to each other through practically instantaneous communication, rapid transportation, commercial, economic, social, and political interdependence. This contact has tended to break down some of the prejudices which have functioned as barriers against advance in understanding of the world situation as it really exists. It has led to a recognition of the need for considering all of the interests in existence at a given moment if we are to attain anything like a satisfactory solution of any world problem. Through this intimacy the degree of positiveness with which each people has assumed its right to be called the chosen of God has been somewhat modified.

This situation has led inevitably to a change in view of the past and future as well as of the present. Just as we must grant the need of accepting conditions as they are for the world as a whole in any given moment, so we come to understand that in consideration of all great problems—whether they concern politics, business, or science—the special significance of present time disappears. We are able to attain satisfactory interpretation only when we recognize that which is, was, and will be as a part of one connected series of inextricably interlocked and interrelated elements in the unity of human relations.

I am afraid that we as American citizens have sometimes seemed scarcely cognizant of the fact that time passes and conditions shift. It is probably true that our democracy is more effective in the space sense at a given moment, as for example, relating Oregon to New York, than it is in the time sense, as connecting the New York of to-day with that of fifty years hence.

Contrary to the commonly accepted view, what have been called the incidental or unwritten evidences of human activity form not only a very reliable record of history, but the bulk of such information is relatively large. The layers of ruins representing successive stages of growth, climax, and destruction, such as we find in Jerusalem or Rome, reaching back from to-day to the remote yesterdays, give us an account which not only supplements written statement but contributes much that is not touched upon in written record. So, as we proceed from modern to mediaeval and ancient history, we have found it possible to study with accuracy and satisfaction the development of cities and civilizations from which there have come to us but few pages of written story.

The field of historical research included in archaeology covers a vast stretch of time extending into periods many millenniums before the Christian era. From this we reach insensibly into the so-called dawn of history or prehistoric period. The existence of man is not limited to the present geological time. Our own history reaches into earlier geological ages and merges with that of the cave bear and the saber-tooth tiger. Man was present as a part of the living world in a period so remote that the range of time compassed by modern history is only as a pin-point compared with the long-extended line represented by these earlier records. Since human beings appeared in Europe the form of that continent has changed; the climate has shifted back and forth from arctic to temperate; and a long procession of living creatures different from those of the present day has passed over the earth and gone into extinction.

The earliest portion of the history of man is found on the later pages of another and longer story read from the strata of the rocks—that magnificent series of records bearing the finger-prints of the Creator. They are laid one upon another in the order of their making, but the series is opened wide for our convenient inspection. This record has been called the greatest original document available to us from all time. There are many chapters of the story. A single author wrote them all. His claim to the authorship was established in the making of the world. The record lay long unread. Its value depends upon the intelligence and genuine desire for knowledge of those who approach it. In these later days the seeker for truth has found it a veritable treasure-house of information.

The record of the rocks, from which we read the geological history, does not cover more than a small portion of the past of this planet, but the strata available, if carefully pieced together, would give a total thickness of something like 300,000 feet, or more than fifty miles. Calculated by various methods, the more conservative estimates of the time which was required for accumulation of this pile are now expressed in hundreds of millions of years, with the tendency continually toward lengthening of the time. Geologists who have made the most recent calculations generally insist on figures representing between five hundred million and one thousand million years.

And yet when we reach the bottom of the pile we find that the

lowest or earliest record available is not the beginning. The earth is so ancient that the oldest rocks have been destroyed. The great number of movements of the earth's crust and intrusions of molten rock that have occurred in past ages have broken and ground them into pieces or have melted them into unrecognition. And now we have little hope of finding the real beginning of the story. Remains of animals and plants entombed in the strata formed in each stage or period represent the history of life. We may not learn when life appeared upon the earth, since we now know the oldest record to be absent. Through the hundreds of millions of years represented in the chapters preserved for us, the world of living things passes before us like a rapidly changing picture in which, with each successive age, the outlines approach more nearly to those of the present, and the continuing growth brings gradual increase in the complication and intelligence of the highest types.

For more than forty years I have been reading this story from the original documents. I have seen a vast array of records. To me they are unspeakably impressive in the clear meaning of their account of progressive growth in the kingdom of living things. The rocks and hills around us assume the significance of a great temple, carrying in its walls a multitude of signed tablets telling how the building was constructed and of the way in which its inhabitants grew to their present estate. I always leave the contemplation of this revelation with renewed conviction that the power which controlled the past from which we come must also guide the future in the making, and that the better we understand the manner of its working, the larger is our opportunity for the pleasure of service in the present.

The greater part of the early history of our earth belongs to the field of the astronomer; and if for a moment we look upon our planet as a subject for examination in this field, we think of our investigations at once in terms of that aspect of being in which the measure of time is translated into distance. The system of sun and planets to which our world pertains is only a minute part of the Galaxy or Milky Way, a great plate-like cloud of stars. For sake of convenience, the astronomer measures space by use of the light-year—which is the distance light travels in a year at the rate of 186,000 miles per second—that is, more than five million million miles per year. The distance across our Galaxy has been estimated as approximately 300,000 times such a light-year.

The flickering streams of light due to arrive in Washington to-night, February 22, 1924, from the stars in the outer regions of our visible universe, began their flight to the earth so many thousand years ago that only with difficulty can we form a conception of the period represented by their journey. On the day of their departure the ancient home of our ancestors in Europe had a geography and a climate different from that of the present. The stars which appeared with the coming darkness flashed their light into the eyes of the cave bear and the lion, seeking their prey in a world of which they were masters. In the same night these twinkling lights must have caught the questioning eye and mind of uncouth men guarding primitive homes and defenseless broods—to which the lineage of philosophers and rulers of the world would later be traced.

To me these remote stars attain full complement of service to whatever power they are responsible by helping with their faint message to give us a measure of magnitude of the *real* world in which we live. They reach far through space and time to tell us that we are each but a speck in space and a flash in time. In the instant of our coming we are already gone. After all, is it not true that the evidence of our ability *merely to know* of the universe as it is, and of our place in it, is a sufficient reward to balance the proof of our littleness in comparison with the vastness about us?

So, seen from various points of view, the whole long story of history has developed. By the combined effort of astronomer, geologist, archaeologist, and student of man's written record, we begin now to visualize the background in space and time through which our world *has* grown and *is* moving. We know that, regardless of the philosophical view we may have concerning man's origin or beginning, there is behind him an almost unthinkable stretch of time, through which, beset by a multitude of dangers, with widening wisdom and power, man found his way to subjugation of the world. Struggle and training have produced in him at this stage the kind of being whose myriad-batteried brain receives an impression of the form and the power of the universe and transforms it into mental life and action. And now, after this lapse of ages, the lamp of history throws its faint rays along the trails on which he walked cautiously through the forest of dangers that time has almost erased from memory. And we are thankful for what the years in the wilderness have given.

Having found it necessary for the moment to touch that wider field of history in which science is thought by some to lay an unfeeling hand upon affairs concerning the relation of man to his Maker, perhaps I may give such assurance as my own conviction can carry that science does not tend to eliminate from the world of things, or of life, or of humanity, that overshadowing power which has been recognized in religion as Creator. The man of science sees the universe as more wonderful with each discovery. The stars, once known only as points in the sky moved by an invisible power, are not less beautiful or less wonderful by reason of our having attained an understanding of their chemical and physical characters, their size, distance, and the nature of their grand march through space. Matter, the physical basis of the universe, is not less awe-inspiring since we have come to see it composed of miniature universes within universes in the molecule and atom.

No one can escape the feeling that, as knowledge advances, the greater world we come to know in terms of space, and time, and power, becomes the object of increasing reverence. Our place of habitation and the period of our existence shrink to relatively small dimensions, but the glory of our part in the plan of the universe increases when we see creation renewed in each successive age, and the way open to us for that continuing growth or progress to which the life of each stage has made its contribution.

So I then repeat what a poet and philosopher has written for us:

> "Let knowledge grow from more to more,
> But more of reverence in us dwell;
> That mind and soul, according well,
> May make one music, as before."

It is necessarily a task of extreme difficulty to make certain whether history gives evidence that the current of human life shows in itself a plan of movement like that appearing in the trend of the life world through the long reach of geological time. It may also be urged that the movement, however defined, may be so slow that it need not concern us as individuals. But the mere demonstrated fact of definite movement, or the determination of its trend, is of surpassing importance. Without large evidence of immediate effect, it can give us a source of faith in the goal of nature and of man. It may furnish a stimulus to make us cling to that which is

progressive and to hold fast those things which make for advancement.

Nearly every people with a history sufficiently long to permit accumulation of legend or literature has set down some form of statement concerning the manner of its own creation or coming into being—and just as we have always demanded knowledge of our origin, so we have craved to know something regarding our end or purpose. A wide acceptance of personal immortality has met the requirement for continuity of individual existence. It has not provided for the future of the race in the sense of organized society, the continuity of which is not disturbed by replacement of individuals.

There is nothing contributing to the support of our lives in a spiritual sense that seems so clearly indispensable as that which makes us look forward to continuing growth or improvement. It is difficult to believe that human life could exist without such expectation. Whatever concerns the basis of this belief is vital, not merely so far as it relates to our future in the race sense, but in its direct bearing upon the happiness of individuals as well.

The value of scientific contribution in the historical sense lies in the evidence which it furnishes that the movement shown in nature through vast ages is an indication of the character of the thing with which we deal. Science expresses the idea of unity in nature and its laws, and continuity in their operation. It makes clear that what we see does not merely concern man and the present day, but is something larger than the present or the past alone.

I should not fail to note that there has been a tendency on the part of some philosophers and leaders in modern scientific thought to assume that, with the present attainment of high intelligence in man, evolution or advance is halted. It has been suggested that our present civilization is a disease and that existing culture and organization will collapse. This reminds us that the story of Adam and Eve tells of their eating the forbidden fruit and suffering the sad consequences of added knowledge when they became responsible for judgment of good and evil. In reality, the eating of the fruit bringing attainment of knowledge should not merely make degradation possible; it also opens the way to a higher estate which could be reached only through knowing the greatest possible good. Man would be unworthy if he failed to accept responsibility

for increased knowledge and for judgment, although it mean the risk of contingent evils along with the opportunity for greater good.

Although the account of Adam and Eve relates that they were banished from the Garden and denied the privilege of living forever in possession of the knowledge they had gained, the gospel of redemption pointed out once more a way to the highest attainment of human life. The principle of punishment was replaced by the Christian law of brotherly love, and the fullest conceivable dedication of life for the good of humanity was expressed in vicarious sacrifice.

It is worthy of note that, in the purely scientific sense, the mutual support among men advocated in brotherly love moves toward elimination of the evils which gratify the individual but endanger society. The recognition by society of those constructive things which are to its advantage tends constantly to build away from the opportunities for evil brought by increased information. The suggestion that civilization will be wrecked because with advancing knowledge new opportunities for evil appear leaves out of account the fact that increasing wisdom brings ability to distinguish more accurately and more quickly between good and bad.

Although we may recognize evils in our present civilization, it is well to remember that in the expression of progress presented in history there can be no expectation of absolute uniformity in movement. The major curves will show minor irregularities. We should not be confused by temporary conditions, but ought to guide our judgment by those evident tendencies indicated by the larger movement visible in the longer span of time.

It is not my purpose to discuss all phases of history applicable to present-day education or research. A group of experienced historians with the highest ideals devoting themselves to this subject stand to me in the relation of teachers, and I am only expressing here my confidence in them. It has been my purpose only to invite attention to those phases of the problem which lend themselves most readily to approach by historians examining the longer reaches of time, and given opportunity to consider changes clearly representing the expression of creative movement.

One of the greatest possibilities which education offers lies in the opportunity for making the interpretation of historical changes

useful in present and future affairs. Good citizenship is impossible without judgment based upon an understanding of the world framed as it really is, and not presented as a distorted picture such as selfish interests—individual, corporate, political, or national—may make it. The proverb, "Where there is no vision the people perish," which was written in the time of kings, may be translated for a democracy and read, "Where the people have no vision they perish." Let us change the notion of completely stabilized ideas in life to one which recognizes that everything in history teaches clearly that we should build with the continuing expectation of change and progress. Let no one vote on matters touching national issues unless capable of interpreting their historical meaning.

Whatever it seems to say about it, the world wants disinterested, progressive leaders in every trade or profession. It does not want and will not have dominance in leadership which tends to sit tight, hold fast, and let others take the risk of constructive work. We are not interested in merely seeing the wheels revolve—what we want is to know that the wheels go round because the cart is moved.

This country has just passed through an epoch of prosperity such as few nations have known. Its success has been due partly to hard work, abundant common sense, and inventive genius, but largely also to abundant natural resources which could be gathered for the taking. This stage now nears the end, and we recognize "conservation"—preferably called "better utilization"—as an absolute necessity. In the development of such a policy for our land, our forests, our mines, our water power, as also for our power of hands and brains, it is only the clearest look ahead for periods longer than a lifetime that can bring success. The mind trained to common-sense prophetic vision, made possible by historical perspective, is the only one capable of realizing the needed organization.

In our future industrial development we shall necessarily depend upon brains and new ideas, at least to the extent to which we have leaned on abundant natural resources. The increase and organization of information by that creative effort known as research will inevitably mark the next great advance of our industries. Some educational and research institutions have long seen it. A number of industries have recognized it, have acted upon it, and are reaping the double reward of a reasonable financial return and

the satisfaction of performing important public service. The planning of our advance in many aspects of industry will require at the same time a knowledge of fundamental natural laws and an interpretation of future needs and research possibilities such as can be provided only by minds trained to the longer vision of events.

It has not been my intention to suggest that history exists solely for the business of prophecy or that forthwith we should all become professionals in this ancient and respected calling; those other functions of history which concern the truth about the past and the origin of the present are also sufficient fields of endeavor in themselves. There is none the less reason for considering that when we think of what might be called the five-dimensional aspect of the world in which we live in the sense of length, breadth, height, time, and creative movement through time, it is especially important to stress that expression of the fifth element, which may represent law or mode of operation in determining the changes.

The Great War stimulated our thinking on the larger meaning of history, and even on its prophetic value. More recently the Einstein theory and the story of Tutankhamen have accomplished much in continuing our education on problems touching the meaning of time and space and change. We are just beginning to learn how to take advantage of experience of the past, and our vision is only slowly reaching with assurance into the future. More than all, we are just now beginning to see what manner of world it is in which we have been placed, and how great a heritage we have in a universe that moves.

In our advance we have discarded the ancient method of change by revolution, punishment, and destruction, for that of evolution built upon continuing improvement and construction. We are trying to put aside the idea of selfish struggle typical of the early reign of tooth and claw, for the mutual Christian support which brings about the highest common good under the rule of truth and law.

As I close, permit me to express once more my trust in history as fundamental in education and a guide in decisions of every-day life. Its message may some time carry to you, as it does to me, a faith in the order of the universe which immediate dangers may not weaken. Though at times our vision seems not to reach into the darkness about us, we see growing ever brighter through the

ages that flame of life from which there comes the light of truth and understanding handed on from man to man. And in this light the way becomes more clear by which we may climb up a further step. So Tennyson's immortal lines float always through my thoughts in that—

> "I held it truth, with him who sings
> To one clear harp in divers tones,
> That men may rise on stepping-stones
> Of their dead selves to higher things."

To you as a graduating class it may seem that my vision lets me wander so far into the future that its value is already lost for present thought or human use—but in a sense it is your future into which it moves. Do not depend upon my eyes, but look yourselves where I have tried to see, and you will search out more than I have found.

In the world to which you now go out you will find the real joys of life lie in service and in building for a better future. Attainment of the first depends upon ability to learn the right relations to your fellow-men. The promise of the second lies in the evidence that, when the germs of life were made, hope and faith were mingled in the seed.

Remember that to-morrow will not be as yesterday. May your to-morrows brighten as your vision widens, and may your willing service bring an ever-growing measure of reward.

TIME AND CHANGE IN HISTORY

TIME has been interpreted in an almost infinite variety of ways, and no single statement can do more than picture it from one point of view. In general terms, the concept of time suggests a mirror reflecting change. According to what it is that changes, and the point of view or purpose of observation, the aspects of time will vary.

In a careful statement on this subject presented by Dr. R. A. Millikan in the James Arthur Foundation lecture of 1932, consideration was given to "time-rate-of-change of position," which is velocity, and "time-rate-of-change of velocity," which is acceleration. These were related to concepts of force as concerning uniformity of nature and natural law, and to the concept of continuity of nature or the necessary continuity of motion and change of motion.

The question presented by Dr. Millikan was discussed in terms of recent views indicating that there can be no absolute frame of reference for motion, the relative motion of two bodies alone being measurable. This formulation links space and time in a "space-time" concept. These views indicate further that velocity and position, or energy and time, are not independent of each other, and that we have no warrant for considering absolute time, as also none for considering absolute length.

In one sense what physicists have discovered is that conceptions of time and space, once assumed to hold consistently, are not really valid except under the special conditions which control in the relations specifically observed. This situation is, however, met in nearly every field of science. Often we assume broad understanding of a group of phenomena from the conditions first examined.

The concept of time, as we use it, generally seems to have limitations comparable to those suggested by present-day application through mathematics and physics. But just as the physicist, even after discussion of limitations on his views of time and space, continues to make measurements and to draw conclusions within

Lecture given on the James Arthur Foundation at New York University, May 4, 1933. Preprint, 14 pp., September 1936. *Time and Its Mysteries*, series I, pp. 23–36. New York: New York University Press, October 1936.

certain limits, so in other discussions involving time-concepts, broad relations are used as basis for discussion of important questions, but with recognition of the consequences due to relative conditions.

Concept of Historical Time

Time in the historical sense may, as has been suggested, be considered as mirroring change. Here also the difficulties of relative position and movement are encountered frequently. They are illustrated by coincident presence of stages in civilization recognized as representing widely different ages in development of man. So we may have the Stone Age culture typified at one locality and the age of applied electrical energy at another.

When we perceive visually certain remote stars we know now that the light which makes this possible began its journey in the Age of the Dinosaurs, and that what we see as of the present really represents an earlier age. If by chance the remote suns which transmit us this light have around them planets on which the evolution of life is under way, the living things on those planets might be very different today from what they were when the light began its journey to this earth.

Method of Measurement

As in other kinds of measurement, it is necessary in the problem of history to inquire as to the method of measuring and its precision. Practically all time scales that concern history refer to the same basis; namely, the period of rotation of the earth on its axis and that represented by revolution of the earth about the sun.

In any attempt to reach finality as to these standards, variation in length of day and year must be considered. From calculation by various methods it appears that small changes may have taken place, but over the ages the extent of deviation from present units of measurement seems to have been slight. Apparently such variations have had little influence upon the scheme of calculation for historical time used as a background against which to project changes in history as we visualize them.

Amount of Time Available

The amount of time available for what may be called history, in general terms, is also a significant matter. Written or other

records consciously prepared by man cover only a few thousand years. And, important as these statements are, sometimes we admit that one of their main values is as reflection of opinion of the writers rather than as record of facts.

Unwritten history of human life presents itself in a wide variety of forms comprising remains and traces indicating life and activities for perhaps a million years. Behind this comes the record of the earth in geology, furnished by every conceivable kind of relic or imprint picturing realities of past ages.

In the sciences of the earth there is a rapidly growing body of knowledge concerning time, as corresponding to the measure of years or revolutions about the sun. Physicists and astronomers have considered the extent of the period available on the basis of limits within which the sun might have given the earth an adequate supply of light and heat. This time appeared at first probably not longer than two or three tens of millions of years. Newer views concerning nature of the sun, and solar radiation, have changed the extent from a few tens of millions to several thousand millions.

In another way the geologist, estimating time on the basis of rates of erosion and sedimentation, has built up figures requiring increasing millions, until limits originally set by physicist and astronomer have seemed inadequate for statement of what the geologist finds.

With the latest phases of study on the age of the earth, what might be called internal evidence has been much refined and extended by estimate of rates of radiation in breaking down of minerals enclosed in the rocks. So the study of uranium minerals leaving in their disintegration process a residue of lead, when checked against refined laboratory observations, gives a possible age for some of the oldest rocks of between one thousand and two thousand million years. In the meantime the calculations of astronomer and physicist in research on life of the stars or suns have given age limits for those units, on the basis of previously unknown physical processes, suggesting a period of activity for our own sun at least as long as the age calculated for the oldest rocks in the geological record of earth history.

In such estimates as have been mentioned figures will vary greatly. For the present it is mainly mode of approach to this knowledge and order of magnitude that are of particular importance. Lectures of

later years in this course will, I assume, give you, as it were, bulletins on the advance of science in this fascinating field.

The purpose of this particular lecture is mainly to direct attention toward the significance of certain aspects of change characterizing what has happened within the period of earth history as evidenced by our record. It is desired also to examine the nature of these changes and to inquire as to conclusions which may be drawn from trends of processes shown in these events, as they are measured in the rough frame of earth time.

Nature of Historical Record Used for Expression of Time

Fragments of the actual historical record of the earth to which reference is made can be found in a thousand ways, and in nearly every region of the earth. But there are places where the story is so clearly real in all its aspects that the mind not only accepts it fully, but uses it as basis of reference for other situations less readily pictured.

Among exceptional opportunities for obtaining an impressive vision of time, the Grand Canyon of Arizona is perhaps the greatest in America, or even in the universe as we know it. Peculiar conditions have exposed an almost perfectly maintained record, and have presented it in a frame of magnitude and beauty which helps to draw instant attention and to make ineradicable imprint upon the mind. With vital reality, the vision of time reveals itself there like the opening of a door upon the past. Even more striking than the contrast of physical grandeur of the gorge with gullies and canyons we have known is the comparison of the great chasm of ages with the measure of passing years as we have fathomed them.

For those who go down into the Canyon to set their feet upon the strands of early time, represented in the rocks, these are places where history not merely reveals itself, but seems waiting to tell its story. With a sense of reality like that of the present, in standing before these ancient records of the earth, we are conscious of the streaming waters that rattled the heaps of worn and battered rocks which now form the walls, or of lapping waves as they spread upon ancient beaches the sands which are today sandstones of the bordering cliffs.

But the meaning of this record is not comprised wholly in the startling reality of the many episodes in history that one encounters,

nor yet in the truth that the sequence in which we find them is the true order of changes in nature. When from some commanding point one looks out over the spectacle, not merely is there apparent the real significance of each of a multitude of incidents in their natural order, but the relation of these differing aspects of the world to each other translates them into an expression of activity extending through time. One sees the mechanism of nature and of history as if with all its parts in operation, and compasses the great complex in a single sweep of vision.

This picture represents in the truest sense an abyss in time cutting across the ages. It shows in clear perspective the reality, the sequence, and the movement in a vast tide of events.

The Grand Canyon is a magnificent spectacle merely as magnitude, or as color, or as illustration of architectural and pictorial patterns, but perhaps more than in any other way it has human value as a means of indicating what change, movement, and time are, and how they present a background for all human thought and purpose and planning. Without such an appreciation of perspective in depth or height, or of the streaming movement in the currents of change, there is little possibility of reaching even an approximation to true vision regarding great events or affairs, whether they concern nature, mankind alone, or man in the world where he is placed, or even humanity in the world which it is proceeding to make for itself.

That portion of the geological history of the earth of which we have an approximately continuous, realistic record is illustrated in a succession of strata, formed under conditions not unlike those known in the present. When pieced together these layers give us a thickness of something like forty or fifty miles of rock. This is not all found at once place, and probably represents a rate of deposition not matched precisely at any known locality. Throughout the major part of this thickness the strata differ little from accumulations being made along the borders of seas or rivers or on land at the present time, and no difficulty is experienced in appreciating the nature of the conditions which obtained when the deposits were forming.

As we approach the earlier portions of this record, increasing length of the period during which these rocks have been in existence means that we might expect increasing modifications due to the larger number of general and local movements of the earth's crust

in this relatively longer time, and to the many agencies that might modify the rocks. When the lower portion of this section is reached, these influences, expressed in breaking, crushing, and intrusion by molten materials from below, so affect the rocks that their original characteristics largely disappear. In the lowest portion of the pile the formations are either materials which have passed through a molten state and, therefore, do not possess their original structure, or they have been influenced in other ways to such an extent as to produce modified mineralogical and physical characters.

So in the lowest or earliest part of the great section of the Grand Canyon the rocks through which the present lower gorge of the river is cut show evidences of change to such extent that until recently there has been doubt whether they were once sediments like those of today, or whether perhaps they owe their origin to some other process.

Regardless of astronomical calculations it would appear, then, that our earth is so old that the earliest records have been practically destroyed, and for evidences of history we must be dependent mainly upon this one thousand to two thousand million years of connected story. Within this period geological events present abundant data that indicate the nature of the earth, its structure and movements, the processes that have influenced it, and the changes that have taken place.

Time and Process as Known from Great Biological Changes

As an illustration of the significance of historical change taken from the field of life science, Darwin's great contribution on study of biological change or evolution was founded in part upon geological and palaeontological records, which he considered in terms of processes involved in the history of life. Darwin states in his *Voyage of the Beagle*, concerning his early work in South America:

> This wonderful relationship in the same continent between the dead and the living, will, I do not doubt, hereafter throw more light on the appearance of organic beings on our earth, and their disappearance from it, than any other class of facts.

And again in his *Origin of Species:*

> Judging from the past, we may safely infer that not one living species will transmit its own unaltered likeness to a distant futurity. . . . As all the living forms of life are the lineal descendants of those which lived long before the Cambrian epoch, we may feel certain that the ordinary succession by generation has never once been broken, and that no cataclysm has desolated the whole world.

The element of continuity described by Darwin is critical, in that it makes possible the process of building. Incidentally, it is this continuing relation that gives greatest dignity to human life, as through it life is fitted into a growing or developing scheme.

The theory of evolution in one form is a historical view of life. It is based on consideration of many factors, but it was seen early as a phenomenon presented in terms of change or time. It ranks among the most progressive and most comforting ideas that mankind has come to know.

Change and the Record of Man

In the historical record of man himself, considered in its greatest extent through time, we have unequivocal evidence of changes corresponding to those known for the long sequence of other types of life preceding man. Human history finds its beginnings in a stage of geological time considerably removed from the present, and marked by conditions upon the earth materially different from those of today. Within the period of history presented, man has himself changed greatly. From what we know of history in other groups, we are led to believe that conditions governing in evolution or development of other living things in some part influenced development of man.

When we consider the record of cultures or civilizations developed by mankind we see tremendous advance in accomplishment, both material and intellectual. Both individual activity and the broader human relations have provided endless variety of contribution through experiments in education, and in economic, social, and governmental organization. Pride of present-day students in the achievements of this particular age must be tempered by recognition of values represented through what has been done in other epochs. In study of cultures and civilizations we know now that not until the history of achievement for all peoples and all times is brought together as consecutive stories shall we be in a position to judge as to ultimate values. Modern education finds itself returning to experiments of the Greeks. And the great group of religions often goes back to the savage to find a relatively safe view as to relation of man both to nature and to other men. Above all we learn that whether you call these changes steps or stages in human evolution, or whether you look upon them as representing that "vision without which the people perish," or whether it is all to be described just as

"experience," they represent movement of events, underlying which there are principles of value to us, and which make the chart of history an important guide.

Impermanence

One of the most significant elements in observation of what happens in the world of things, inanimate, living, and cultural, is the seeming impossibility of permanence for anything, unless it be truth itself and the evidence of its application. Next to the laws of existence, the modes of change are among the most important aspects of being. So a poet has recognized the significance of this flow of events in the words:

> Weep not that the world changes—did it keep
> A stable, changeless state, 'twere cause indeed to weep.

Without assuming that all changes and modes of change can be reduced to anything like simple formulae, the records covering history of the earth and life, and all the movement of events which we know as history in its various phases, must be looked upon as evidence regarding the nature of the things with which we deal. Almost infinite complications make difficult an interpretation of much that we see, and we may not expect full understanding immediately; also the question as to why these things happen is one which science is commonly not in a position to answer. Many of the events will not easily resolve themselves into terms of what we call cause and effect as limited by description of the physical world. And yet it would be difficult to set aside these trains of events as wholly unrelated.

That history has value as experience, and that it suggests processes or modes of action does not therefore give it infallible prediction value. One of the most important evidences of history concerns the fact that nothing remains the same indefinitely—in other words, that history does not commonly repeat itself precisely. Situations already formulated may remain, but changing conditions bring new results. Prediction values may not be considered generally as clearly defined, but rather as indicating that certain situations have possibilities of a particular order.

Time and Life

Time, with the changes which it represents, gives to life and the world of things to which it is related an increased value suggesting the difference between the surface of a flat, unchanging world, and our place in a wide, deep universe of things in motion.

Now that we know the earth to be round, we look with amusement on those who conceive of living on a flat world. To them, not only is the earth different, but the heavens above must be wholly different from the universe round about us, as we see it. Equally interesting is the common absence of perspective in time, both in retrospect and prospect. To persons who lack this aspect of vision there is no element of depth, and no range within which developmental types of movement could take place.

The greatest value coming from our vision of change and time and their consequences is the idea that the world moves, and that what we do is important for coming generations. This will be true whether we build for the future, or reduce our opportunity by degenerative or destructive pleasures which waste the store of materials that the past has accumulated.

If there are laws or well-defined modes of procedure in history, is it then possible to consider whether by their use we may better existing conditions? Especially would this be desirable at a point where in practical affairs it becomes necessary to consider in one picture the entire earth and its inhabitants. The greater problems of today must be discussed not only in terms of world geography, but on the basis of world history as well. If isolation in space and time is really desired by any group, the best course is to find another planet, one that is perhaps bombproof and rayproof, and to which, across the frigid ocean of intervening space, no message may ever pass.

GEOGRAPHY AND HISTORY AMONG THE SCIENCES, AS INFLUENCING RESEARCH IN THE AMERICAS

Geography and History

Depending upon the purposes in mind, to some it has seemed possible to demonstrate that geography and history are broadly inclusive of the sciences, and to others that these subjects do not themselves represent what has been called science, but only points of view.

In geography the wide scope of materials involved has made necessary the use of data representing many phases of natural science. Those include geology, meteorology, the vast variety of life, and that course of evolution which led to the present location and adaptation of life. Just as we can understand how geography came to include much of science, so we can appreciate also the tendency of many specializing subjects to draw away from geography the organized data of geology, meteorology, plant and animal distribution, along with anthropology, until the movement tends to divest geography of what seemed its greatest assets.

History has in some respects fared worse than geography, as its tie with the story of man has led many to insist that it never can be included in the sciences. Whether or no we believe the foundations of history to rest upon realities and their logical or philosophical interpretation in the sense in which this is true of the sciences, there has been in this subject also a record of broad accumulation of data covering many branches of knowledge, succeeded by a period of stripping away individual subjects claimed by highly organized special departments of knowledge. As illustrating one aspect of the problem of historical science, I feel qualified to speak personally, having spent a considerable portion of my life in struggle over the

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question whether my chosen subject of paleontology belongs in geology or in biology. My own view has been expressed consistently to the effect that paleontology relates intimately both to geology and to biology but is dominated by the point of view or attitude of history.

The thesis which I plan to discuss concerns the idea that history and geography are both founded upon principles comparable to those governing science as commonly defined. Each subject may be expanded naturally to cover much of available knowledge regarding the world and its inhabitants. In the process of such reaching out to touch other fields, each may profit greatly by this relation. In spreading, either may lose itself in a maze of materials perhaps better considered under the head of other special subjects. It is my desire to call attention, on one hand, to the broadly inclusive nature of both subjects, to note their intimate relation to the sciences, to emphasize especially the features which characterize each, to suggest the necessarily close relation between the two, and, finally, to suggest certain questions of immediate importance in which these special points of view are desirable in the attempt to obtain solution of special problems in the Americas.

Advance of the sciences has been characterized by intensive, rigorous study of the characteristics of what we call realities, by examination of the relations of these materials to each other, and by attempt to discover whether the processes illustrated show such consistency of procedure that we are justified in accepting them as dependable. Definitions of these modes of procedure we call laws. Such organized knowledge simplifies enormously the handling of day-to-day problems. It not only makes possible activity in a natural world without the necessity of treating every act as an experiment, but it opens the way for advance of civilization through formulation of information constituting the foundations upon which new constructive activities may be established.

As has been suggested, the value of these laws is sometimes stated in terms of dependability; in other words, with relation to existence of qualities which lead to expected action. The dependability is often checked by experiment, which has become a favorite means for testing modes of procedure or laws. In another way we picture these conditions of operation by expressing them in terms of prediction value. We attempt to learn how far we can depend upon the

operation of natural laws to act so closely to known patterns that we will be able to predict the outcome of forces seen in action.

This prediction value, or reliability, comes to have great human significance in our relation to nature, and in study of activities in human kind as well. If corn is planted, may we expect a crop? Can we look for consistent prediction of weather? Will eclipses and tides appear on schedule time? The application of this criterion of prediction has come to be used commonly as an important point in definition of a science.

To some, the requirement of procedures described as laws influences application of the term "science" both to geography and to history, but in each subject it is also important to recognize the element of variability or change as itself something to be considered a characteristic. The extent to which dependability or predictability is expressed in these fields is still a subject of discussion.

The degree of dependability or predictability in a subject such as geography must necessarily be quite different from what one finds through experimentation in such fields as physics or chemistry. Dealing, as geography does, with the relation of elements on the surface of the earth, or in space, it might be said that predictability or dependability would relate to whether the things arranged in space may be depended upon to maintain their characters in a particular situation. But geography is not limited to consideration of distribution in space. It relates to the fact that in different situations with varying environments many of the controlling conditions vary.

So far as prediction is concerned in geography one might inquire whether given the location of a particular thing at a particular place on the earth certain types of conditions might be expected. At an early stage in development of world geography, there would have been question whether with the knowledge available to Columbus he could predict that curvature of the earth would extend itself in such manner as to give spherical form, and offer the possibility of sailing to the Indies by a path to the west. In the field of geography as it touches biology one might inquire whether given knowledge of the form of the earth, with variation of the seasons due to position of the axis of the earth, we could depend upon certain types of environment which would favor particular kinds of plant growth.

In history, the value of available knowledge for use in logical construction of generalizations or conceptual systems is sometimes

looked upon as less satisfactorily founded than in the sciences generally, or in geography. While in our treatment of the materials of history we demand, as for all sciences, the most rigorous scrutiny of experiential data, the degree of dependability is commonly reckoned as less marked than in the basic physical sciences. The extent to which history has prediction value is of course one of the vigorously discussed problems, especially in its application to development of human affairs. Commonly, however, there is failure to take into consideration the fact that some of the most important contributions of history, such as those which are represented in the theory of development, or evolution, emphasize particularly the idea that history does not repeat itself precisely but represents rather a mode of change in which certain of the more fundamental elements, which might be called generic, may maintain themselves, while details change continually.

In some measure the prediction aspect of history points toward the idea that precedent conditions will not be repeated exactly, but rather will the generalizations formulated lead us to expect states to a considerable extent new. For example, when we look over the story of life recorded through some hundreds of millions of years, it is difficult to avoid the conclusion that modification of organic types is the rule, whatever the reasons or causes may be. In the same manner, in examining the broader outlines of human history so far as the physical background of man is concerned, one finds similar trends.

Application of the basic principles of science to history with particular relation to human affairs involving cultural, intellectual, and spiritual values presents the most difficult of all problems in this field, since there is general acceptance of the idea that human life offers the possibility of choice or of a certain freedom, which in itself interferes with the rigid application of what we have termed "natural laws."

Whatever the complications arising from interlocking of geography and of history with a great number of other fields, each of the two subjects has made its contribution in the interpretation of data in these other areas of thought. Geography has defined variation of materials and conditions in space, and has contributed data needed for understanding the nature of contrast, variation, and evolution or development in space. History has been the measure

of time and change, touching all things inanimate, animate, and human. The record of its movement must be examined by methods comparable in exactness, organization, and purposes of interpretation to those of the sharply defined sciences. Whether or no the modes of procedure are as simple and as clearly defined as those of physics, they are not less important and should be used so far as we can interpret them.

Definitions by Kant

In his lectures on geography about 1765 the German philosopher Kant considered knowledge regarding the world based upon experience and reason, and practically defended geography as description in the order of space and history as description in the order of time. Perhaps continued reaffirmation of the specific objective in each of these subjects as given by Kant would accelerate the advance of knowledge. Especially would this be true if there were rigorous application of the methods of science in both subjects and insistence that other phases of thought or investigation should aid in preparing the materials for discussion in these two fields. With this attitude each subject would be a point of view or mode of inquiry, for use of which geology, zoology, botany, anthropology, and other fields would furnish the concrete materials.

Relation of Geography to History

The difficulty of separating either geography or history from other subjects cannot be illustrated better than by considering the relation of each to the other. For example, the geographical variation of life types in relation to differing environments comes about commonly by way of migrations through space which are recorded in time as history. Variation of the organisms through the ages corresponds generally to variation in a measured spread through space. The nature and the rate of change may be measured usually either in space or in time. Actually they are recorded in both.

Next to values that reside in the fact that things have being, and that life brings movement, we may well look upon the variety and change incident to geographical distribution, and to development or evolution through time, as among the greatest conceptions regarding the world about us. The extent to which these situations and rela-

tions are subject to the conditions required by science depends mainly upon the degree of intensiveness in examination of the realities concerned, and upon the unswerving logic of the philosophical interpretation. It may be expected that the almost infinite range of complications presented will make full understanding seem beyond the possibility of attainment in much of what is undertaken, but the objective should be found in honest understanding rather than mere formulation of hypotheses to be put into circulation as foundations for the building of ideas.

So significant do the points of view of geography and history appear, that, at a time when citizenship carries real responsibility for knowledge, it seems reasonable to take the view that no person should be considered educated until he has experienced the actual construction of a map representing the elements of distribution of something, and has engaged in following out the development or history of a particular situation or idea illustrating sequence in time.

Application Values

Just as in estimating the value of laws in science we judge on the basis of applicability in handling the great volume of data encountered, so the significance of such comments as have been made regarding definition of functions in geography and history depends upon applicability of these conceptions in the interpretation and use of facts or situations with which we deal in human relations. One may ask properly whether application of these views can help to define the kind of action necessary if the best human use is to be made of materials and ideas available.

There is perhaps no situation in which the values in these concepts of geography and history would appear larger than in consideration of requirements of the scholarly and practical interests represented in this particular gathering of students from the various nations of America. The portion of this earth occupied by the Pan American peoples covers a geographic range extending over much of the distance from one pole of the earth to the other. Without even considering the exceptionally interesting history of America since its penetration by European peoples, we have here a very long record, which is peculiarly valuable because its development seems to have gone forward along courses which were relatively direct as compared with much of the story in the Old World. The conditions presented

in the Americas are therefore in some ways exceptionally favorable for considering applicability of basic principles of geography and history in the sense in which they are here described.

Geography

If one consider the question of dependable, and in a sense predictable, conditions represented in geography, or in space, over these American regions, there appear in practically all aspects of nature features which are characteristic of geographic regions or zones. Most evident of these features are the areas defined by climate related to astronomical influences. Other regions are limited by factors of other types such as the distribution of land and water, or exceptional variation in elevation of the land. Regardless of theories developed to account for its occurrence, the vast variety of life on these areas when located on a map scheme shows correspondence to areas defined by variation of climate or by other differences of environment. We have tested out in various ways the adaptability of these kinds of living things to different types of surroundings, and discover that they are in large measure limited to possibilities of successful growth under particular conditions. Among the kinds of life thus defined as to geographic location are many which have important economic use. Others expressing various pathological states are inimical to health.

From the point of view of geography, history, economics, and health the geographic factors which touch life in the American area should have the most careful possible study as to identification, character, distribution, and their significance in relation to human life. Not to know the values represented would be to lose assets that are a part of the setting in which human kind is placed. The broad range of territory which we have discussed is occupied by many peoples and nations linked by the relationship of the Pan American Institute of Geography and History. It would seem an especial responsibility of the Institute to consider measures through which it may help to see that the geographic and historic factors are adequately stated. This will naturally involve cooperation with many agencies devoted to special research on subjects of a concrete nature, such as botany, zoology, and geology.

It may also be a responsibility of this Institute to examine present and future needs as to maintenance of existing values in natural

features which depend upon geographic location, such as types of life distinctive of particular regions, or economic values in life most readily produced in certain regions. Insisting that this be done would be a contribution for human good, both to the regions particularly concerned, and with respect to mankind in general. Such action might well have the support of all the American peoples.

From the side of science, considered merely as basic knowledge without reference to its immediate economic application, it is desirable that there be protected for present and future study some of the greater illustrations of natural phenomena over the Americas. These features should be maintained in precisely the condition which has been developed through those great stretches of time in which their creation or evolution has been in process. Reservations of the type suggested have been made by a number of countries, and careful study has been given to this problem by many organizations in several countries. Through the Department of the Interior of the United States a series of reservations has been made in a National Park system. Important reservations have been set aside in other countries, some of the most significant of which are those established in the various parts of Africa. A group of areas set aside in the Belgian Congo in some respects presents the closest approximation to complete protection thus far obtained. In that region important sections are protected against all entrance for a considerable period.

While important advances have been made in protection of great natural areas for their scientific, economic, and educational use, decision as to just what should be done, and how it should be accomplished requires an extended period of study. Cooperation of the several countries in examination of needs for reserved areas for these purposes is a task which could be taken up to great advantage by the Pan American Institute of Geography and History. A central committee, with representatives from the several countries, could make extremely important contribution toward advancement of our knowledge of this problem. The information secured could then be made available to the Institute and also to the countries concerned, with the hope that action would be taken by the governments controlling areas looked upon as desirable for preservation.

In the light of past experience by various countries, it is recommended that proposals for the reservations suggested should concern

natural features of major importance characteristic of particular geographic areas or regions. The reservations should be made with expectation that they will be useful both to the countries concerned and to the other nations of America, as also of the entire world.

In past movements to preserve great natural areas for their intrinsic values there has been a tendency to defeat some of the most important purposes through attempting to secure support of the effort by special promotion of accessibility to these regions. The tendency to develop accessibility, increase the number of visitors, and advance that form of utilization described as playground use, commonly intensifies wear and brings introduction of artificial elements designed to protect, but often reducing the original values. A program looking toward protection may properly recognize the desirability of permitting use which relates to interpretive or educational value, but with the assumption that such utilization will not become destructive. It should also be recognized that, in development of plans for use, the personal effort and financial support used in developing accessibility should at least be matched by effort and support directed toward securing as full knowledge as possible of the elements in nature which it is aimed to protect.

Corresponding to what should be done to preserve natural features of interest by reason of their geographic distribution, and to study their scientific, economic, intellectual, and even spiritual values, it is important to give attention to biological or other natural elements inimical to human life, which seem to have dependable or predictable geographic location. Climate, in the sense of physical conditions alone, has long been the subject of discussion as to its influence in this respect. As noted by Dr. Richard P. Strong in his statement on "The Importance of Ecology in Relation to Disease," just published in the journal *Science*, this is a field in which intensive investigation is greatly needed. An important book by Dr. E. B. McKinley on "A Geography of Disease," which appears during the week of the meetings of this Institute, presents another view of the distributional, environmental, or geographical factor as related to influences inimical to human health. Geographers concerned with problems of the Americas can make no mistake in helping to forward such researches as advance knowledge in this phase of science and its medical application.

And so in very many other ways one might note natural features,

or phenomena, which in their normal expression represent dependable or predictable influences that can be defined in terms of space relation. In astronomy we note that locations in the Southern Hemisphere offer the only means of entrance to vast reaches of our universe not visible through great telescopes of the north temperate zone. Even the earthquake demon, rising from its hidden lair from time to time to spread destruction and instill the virus of fear, is traced to special places upon a map.

It is not my function to list all that may be described as dependable and predictable in the geographic sense, much as I might wish to go further and consider in how far location and environment, in conjunction with history, are responsible for those variations in attitude, vision, opinion, and belief which make it possible to place upon a map even some suggestion of spiritual differences among men.

History

The special problems of history in relation to geography in the Americas present a great variety of difficult questions involving the peculiar values of this subject already considered.

In its scientific aspects, some of the closest relationships of history are with geography, and, so far as discussion of elements of the natural world is concerned, these two points of view are frequently so intimately connected that they must be considered together. The scientific phase of questions relating to history has been complicated by a great number of factors which we appreciate only in part. One of these apparent complications concerns the relativity feature of time discussion, leading to formulae not merely difficult to interpret but applicable only when we know the situations to which they are fitted.

History needs the application of such methods for identification and classification of its basic facts as will give materials for study comparable to the fundamental data used in research on natural sciences. It is well to remember that the units utilized as a basis for research in the natural sciences passed through many stages of refinement before the present status of knowledge in these fields was reached. There is also required in history rigorous application of logic in the study of sequences, at the same time recognizing fully the meaning of the personal element and the degree of variability in such factors. It is also necessary to attempt simplification of

problems in history, and to guard against building over-large structures upon small foundations. It is better to be conservative and say that we do not know than it is to assume that because a judgment is important therefore the decisions made are correct.

Present programs of various nations concerned with different types of forecasting or planning vary in their characteristics from expression of schemes rigidly defined by mathematical calculation to studies in which the trends of economic situations, of society or of government are studied with a view to determining what can be obtained safely from the past as experience. One may, I believe, assume that structures made of rigid materials, pointing unswervingly in definite directions, may suffer to some extent by reason of inadequacies in their foundations. Perhaps the whole idea of planning will suffer because of over-confidence in use of inadequate data. On the other hand, the idea of looking forward, coupled with the effort to build safely, and for the longer time, on soundly tested materials should make for greater security and for continuing betterment of the opportunities open to mankind.

In this particular gathering of scholars it is interesting to note that the view of the history of life known as the general theory of organic evolution, as expressed through the writings of Darwin, had its foundation of reality largely in the succession of geological formations and their contained fossils studied by Darwin in southern South America during the course of his voyage on the ship *Beagle*. You will find in Darwin's *Origin of Species* that this historical conception, with the idea of change in geographical distribution of organisms, furnished large stimulus for later studies of experimental type regarding the origin of species and the forward movement of the life world in past ages.

In the field of operations of the Pan American Institute of Geography and History there is an extraordinarily interesting opportunity for development of a unified program for study of history, human, biological, and physical, in relation to clearly defined geographical features. Although the program appears, and will continue to appear, infinitely complicated in development of its details, the interlocking elements may be more simple than those of the Old World with its larger land areas and more complex migrational influences.

The beginnings, and the initial developmental studies, in prac-

tically all of the American countries present an expression of ideals which, if carried out, will give one of the most interesting statements to be obtained, regarding both the general life world and human history.

Such studies as those involving the history of population distribution concern problems which are among the most interesting questions in the history of migration, and at the present time have great significance in consideration of many critical problems of economics and government.

Among the primary essentials for success in this work in America it is desirable to class the requirement for intimate relation on the basis of scientific approach between those influences which have to do with geographical distribution and the factors which concern succession or movement through time. It will be important also to follow the intimate study of certain special problems of history considered to some extent in isolation. But especially desirable is it to conduct the whole program of investigation with a view to seeing the relation of history not only to geography but also to all of the various general and special phases of science which may be represented or which may impinge upon the historical program. With all of their importance as representing specific points of view, geography and history must literally stand among the sciences and participate in their results by use of these methods.

In discussing opportunities of this Institute for service in the field of geography I have already called attention to the need for protecting and maintaining such natural features as have exceptional significance in the geographic sense. It is important to emphasize also the fact that since practically all of these features illustrate the result of age-long development, they may be as significant in the sense of history as in geography. The value of such protection as may be given will depend in considerable part upon the possibility of making it effective to such extent that the historical values will not be lost. What belongs to the past cannot be replaced once it is lost.

In preservation of remains that represent the history of human development much has already been accomplished through initiative of the American countries individually, and on the basis of recommendations by other conferences of representatives from these countries. But it may not be inappropriate to suggest that the final

value of work made possible by the strong position taken by the American countries depends upon the possibility of even further advance. The story of American history can be written only through close cooperation in research by many institutions and many peoples. Conferences such as are made possible by this Institute promote cooperation through discussion of problems of general interest. Perhaps such conferences may aid in calling attention to the need for locating, mapping, and giving close protection to areas of historic remains the records of which will be necessary in any final summation of American history.

From another point of view it is important to continue the emphasis already placed by many institutions and nations upon guaranteeing guardianship of all historical records in such manner that their full value may be maintained for future generations of students. It is to be expected that others will wish to approach study of certain of the major historical questions from points of view quite different from ours. There should be opportunity for study by these later investigators on a basis as nearly as possible comparable to that of the discoverers, or first researchers. No future student will wish to find a manuscript or a printed document so worked over or modified as to cause doubt concerning what the writer intended. Changes by the author on his own manuscript would be valuable, as indicating shades of his opinion, but subsequent modifications prevent accurate study. The meaning of an ancient ruin, a shell heap accumulated by human hands, or a small exposure of a geological formation may in large measure be lost through over-excavation or through restoration.

In conclusion may I make the further suggestion that difficult and long-extended as is the task of historians concerned with the past of America as guide for the future, I believe the work to be humanly one of the most important to which financial, intellectual, and—shall I say—spiritual support and encouragement can be given by institutions or by governments.

INTERNATIONAL COOPERATION IN HISTORICAL RESEARCH

With widening knowledge it becomes evident that no great human problem can be solved without intimate understanding both of what is happening in many parts of the world at one and the same time and of the historical steps involved in the development of present situations. Study of the growth or evolution of these conditions or ideas may be recognized merely as representing some one of the subjects under which information is classified, such as economics, sociology, government, etc. From another point of view this successional aspect of events is the special field of historical research having as its peculiar function the interpretation of facts relating to development.

Historical research has therefore become one of the most important means of obtaining a satisfactory perspective in examining many major questions touching human relations of to-day. Through it we secure a better understanding of the nature of the materials with which we deal and an idea of the movement of affairs leading into the future. This view of many problems becomes particularly important as it visualizes in some measure the trend of those movements of such magnitude and of such slow operation that we can control them or accommodate ourselves to them only through effort extending over periods which are relatively long compared with human life.

From a practical point of view we have become accustomed to considering as important only those things which are immediate in space or in time. We know now that determination of events in the near future may be dependent upon circumstances originating in relatively distant regions and in remote time. As an illustration: It is possible that the political situation in the United States within the next four years will be determined by the financial status of a large group of our population engaged in occupations

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directly dependent upon agriculture, the character of the crops may depend upon what we choose to consider exceptional weather conditions, the state of the earth's atmosphere guiding the weather may be due to minute but determinative influences arising from variation in the radiation of the sun, and the variations in the sun may be attributable to little understood physical changes within that body. The historical study of such changes in the sun would be one of the factors necessary for understanding of the physical process involved. Such study might make it possible to obtain some understanding of the future of the sun, of our weather, and of all that is dependent upon it.

In the investigation of practically all human problems, whether they represent questions of economics or politics, or touch the study of purely physical phenomena in ancient history, we commonly face the necessity also of securing data from a wide range of localities before ultimate interpretation is obtained. When it is the historical aspect of a question that is considered, the complication of relations and interlocking influences is increased in proportion to the length of time involved. For example, it is possible to conduct a most interesting investigation of the archaeological history of the Maya people of middle America through study of one site or city, but it would be futile to attempt any complete interpretation of this history without a wide range of information touching at least the history of the whole middle portion of the American Continent.

According to the subject that one may be considering, the world may be classified in regions or provinces in which there is relative uniformity or unity in historical process. As now divided in political or national units, we may find little correspondence between the boundaries of national units and those provinces denoting relative unity in history. In considering the greater questions of historical research the record in the region occupied by any one nation is therefore frequently interpretable largely by that available in the territory of other nations, and the cooperation of students in these neighboring countries is necessary for understanding of the history of the whole region or any of its parts.

In a general way this is now the situation for the American Continent. No area and no national unit is historically complete in itself. The United States must cooperate with Canada and Mexico in order to write the story of its floras, its faunas, or its people.

The fact of separate national units with boundaries having little relation to unity in historical process places upon each nation two kinds of duties relative to study of the problems of history with which it may be concerned:

(1) Each nation carries the whole responsibility for guardianship of all data or records within its territorial limits. Such guardianship concerns both those things which relate to one nation apart from others and those which have to do with general questions touching wider regions including several national units. Inasmuch as understanding of certain general questions of history can be solved only by aid of data secured from several national areas, each nation has a moral obligation to the others to protect whatever is of importance to them, and should at the same time hold other nations responsible for what they possess which is of importance in the study of its own problems. (2) The ultimate understanding of much that is of first importance in history depends upon the cooperation of each nation with other peoples in the working out of all problems of mutual interest—both in the investigation which is in its own territory and in that which bears upon the same questions but is in other areas.

If each nation accepts both the obligation to protect its records and the opportunity to cooperate in the study of historical questions to which it is in a peculiarly favorable position to contribute, we will be able to secure the interpretations of history so urgently needed for use in the study of many difficult human problems.

In a study of the Americas we find no marked exception from application of the abstract principles relating to cooperation in historical research considered in preceding portions of this paper. Whether we are concerned with the progress of events relating to general international questions or with matters of more limited scope, it is almost invariably true that the interpretation we seek is obtainable only through examination of a great number of factors touching many peoples. Nor do these principles differ in the degree of their application as between periods approximating the present and times representing remote ages. Their significance is again similar whether we are touching the meaning of economic principles of immediate interest or what may seem like less practical human interests represented by the art or aesthetics of long vanished civilizations.

As illustration of the interweaving of influences, we find the history of economic development of southern United States inextricably interwoven with that of England, Spain, and France. It is related closely to the origin and growth of practically every American nation on both the northern and southern continents. The development of the institution of slavery in the Southern States of the United States had its intimate relation on the one hand to Africa and on the other to the history of the North Atlantic States from which it was later excluded. The interesting series of cultural stages represented in the archaeology of New Mexico and California on the one hand require the close cooperation of investigators in the Republic of Mexico on the other side.

Without assuming that our American history has as its function the interpretation of present and future conditions, it becomes merely a means for the exercise of the faculty of curiosity, and can teach only by analogy. Given the idea of continuity or the recognition of cause and effect, this history does not merely accumulate facts. It becomes a contributor to the definition of laws or modes of procedure in affairs or conditions of environment touching existing human life. The fact that certain great civilizations rose, blossomed, and withered in ancient America would actually be a matter of little or no concern to the people of to-day were there not reason to believe that the development of these civilizations may teach us something regarding both the nature of man's relation to his environment in these regions and the trend of human organization under conditions different from those which have governed its growth in other parts of the world.

By reason of the fact that the great civilizations which have most definitely influenced the progress of modern life have originated in the Old World, there has been a tendency to neglect the abundant historical materials represented over a considerable portion of the American Continent. But it is only in recent years that we have come to realize the true meaning of world history, and to understand that even in Europe and Asia the events upon which our attention has been focused represent only a small part of the story of the growth and progress of mankind. It is probably true that coming generations will look more and more to the story of the Americas as playing an important rôle in furnishing materials needed for interpretation of the nature and method of growth of human organization.

There can be no doubt regarding the great importance of securing from the records of history and prehistory available in America every particle of evidence which may be useful in the interpreting of the story of this region as a whole. The mutual understanding and support of all the interests and peoples involved in this study will ultimately give to each investigation and to each locality the largest possible measure of result. The furtherance of such a relation will of necessity involve that close friendship and cooperation so essential to success in all major human endeavors. It will not necessarily imply elaborate organization or the devotion of great energy to the preparation of plans. The essentials are: First, a clear view of the philosophic significance of the subject and the wider scope of the field; and, second, intensive effort in the development of specific projects in the different countries, each piece of work being considered in the light of its importance for understanding of the large problems.

SOME ASPECTS OF COOPERATIVE RESEARCH IN HISTORY

The materials presented in the following paper originated from examination of a research opportunity in which certain peculiarities of the situation made necessary a special mode of attack. Importance of relationships developed among the various subjects used in this type of investigation has suggested that a discussion of methods of work applied might be useful for other fields of historical study.

The special problem in this investigation concerns methods of research used in studies on history of the Maya people of Middle America. The region involved includes southern Mexico, Guatemala, British Honduras, and Honduras. Although perhaps not comparable to the greater civilizations of early periods in the Old World, the Maya culture evidently illustrates the highest level attained in America before advent of Europeans. The time covered in development of the Maya civilization extended over a period of at least two thousand years. The results of work done by this people are seen now in huge groups of ruins comprising splendidly constructed and beautiful buildings assembled in what may be called cities. In many places these remains are so numerous that from the highest structures in one group there seems almost always to be in view another city of similar type. The general planning of the cities, the stonework, sculpturing, architecture, painting, the hieroglyphs, and the highly developed calendar are each and all so interesting and important as to demand attention among the important contributions of early time. It is often remarked that could certain of these ruins be transported in their entirety to an area within the environs of New York, Paris, or

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London, they would be objects of special interest, even alongside the extraordinary achievements of modern time.

As a living, constructive influence Maya civilization has disappeared. Largely the jungle has swallowed the shattered ruins, and one tends to think of this extraordinary story as finished. But in whatever way one views the picture, we must look upon this adventure in human culture as among the most interesting experiences of mankind. In making comparison of what was done in the Maya area with achievements of the human race in other parts of the world, one is impressed with the idea that this civilization developed largely in isolation from the Old World. There may have been connections, but in the main this effort was independent of what was being done in creating the great cultures of the Old World.

A story so spectacular as that of the Maya naturally attracts the archæologist, who directs his interest toward interpretation of the wrecks of buildings and the ruins spread widely over the landscape. But in undertaking systematic study of this region with a view to obtaining an understanding of the people, their major interests, and the evolution of their culture, we cannot avoid being impressed by the difficulty of extracting from heaps of stones covered by the jungle the story of a people whose skill and art, whose ideals and aspirations, were realized in considerable part through these inert materials, upon which the imprint of their culture has been stamped. At once one asks: in attempting to interpret the story of this people, what aids can be obtained in addition to the regulation methods of archæology? This is in effect the problem presented in the following comments.

In reviewing the materials available for interpretation of Maya history, we find at least two groups of data of great importance in addition to those obtained from the archæological record. The method represented by the *first group* involves study of the descendants of the ancient Maya, with a view to obtaining, through examination of what is inherited, some appreciation of the point of view of the earlier generations. As the Maya civilization has practically vanished, we somehow receive the impression that the people themselves are gone, but there are several hundred thousand Maya now living in Yucatan, and more than one million in Guatemala. These are in general terms descendants of the race that built the temples and the cities. But the people of these regions

today are presumably not exactly similar to the Maya of one thousand or two thousand years ago; one assumes that they have changed somewhat in physical characters and certainly in the cultural values utilized. On the other hand, it may be true that much of the physical, and a considerable part of the cultural, makeup of the Maya today either duplicates or copies closely the characteristics of their ancestors of early time. At any rate, these people of today are an outgrowth of such a nature that we may see through them something of the type of the builders of the early civilization.

A *second group of facts* with which one may properly deal in attempting to learn something of the origin of the Maya civilization is found in study of the environment in and through which the culture and civilization developed. In general, the Maya today are found in the region occupied by the ancient civilization. There have been migrations back and forth, but the physical and biological aspects of the area seem closely similar to those of the region occupied by the ancient Maya. It is therefore important to know the nature of this environment sufficiently well to permit obtaining an appreciation of the influence of these surroundings upon the people now and through past ages.

Study of the influence which environment may exert upon human life is always a difficult problem, but there are many features which give valuable information regarding our dependence upon environment, and others in which the general effect of the surroundings is clear, although we do not yet know the details. One may not question that the Maya were dependent upon the physical and biological elements of their environment for food and raiment, and for many of the smaller things of life which, like our luxuries, perhaps seemed essential once habits of living were developed. The Maya were dependent upon their immediate surroundings for the stones out of which their buildings and carvings were formed. We know also in general the extent to which these people were limited by water supply, and the means which they were obliged to use in order to meet their wants.

The representation of wild life in the environment seen in ornamentation and art of the Maya expresses a relation in the thought of these people to the features of their surroundings. So we see forms of the rattlesnake, the jaguar, and many other creatures, appearing

frequently. How far such illustration of the living things in their environment may have reflected their philosophy and religion we do not know, but these are problems to be considered in examination of the factors influencing life of the people.

One will appreciate the significance of environment and its influence in attempting to make acquaintance with the natural world in which the Maya live today. This is suggested in examination of the long series of natural objects, materials, and phenomena, from study of rocks and minerals through biology to consideration of the general grouping of natural features in different regions. In such a research it is necessary to have cooperation of representatives from many fields of science.

So in approaching problems concerning development of the Maya civilization, it is desirable to utilize every factor which bears upon possibilities of origin of this culture, commonly considered as largely, if not entirely, an American product. Instead of depending upon possible sources in other and earlier civilizations, one looks more closely at the materials out of which through the ages characteristics of Maya civilization may have developed. We expect archæology by its methods of attack to give us the means for working out the successive stages of culture. Such studies will include stratigraphy of the cities, buildings, and débris heaps, and comparison of ceramic types together with development of artistic and other cultural features.

We expect a study of the Maya people of today to give us some understanding of the types that developed through the past 2000 years. In this investigation we shall be aided by the representations of human beings found abundantly in sculpture and painting on the ruins. In this part of the research we need every contribution that can be made by anthropology, nutrition, ethnology, medical history, the study of language, sociology, government, and religion. The analytical and synthetical study of results should furnish us much information which, taken with the archæological record, may contribute toward understanding the story of development of the people themselves through the known period of their history.

Through scientific examination of the environment in all the phases by which we may investigate it, we should expect to make acquaintance with the matrix in which the people live today, their

dependence upon it, and their reaction to it. The data thus secured, taken with those from archæology and study of the people, will go far toward informing us regarding the resources upon which the Maya drew for maintenance of life, and concerning some of the factors as well which influenced their intellectual and spiritual being.

It is important here to repeat that had the Maya civilization been nearer geographically to that of western Europe, or had it been closer to known civilizations of the Old World, the study would at least have appeared more simple. But isolated as the civilization has been, and growing up, as it seems to have done, in this isolation through the period of its development and its decline, there is presented a problem showing elements of exceptional difficulty as well as of unusual interest. Hence the reason for attack from all directions in order to secure information bearing upon the origin and development of this cultural unit.

It is desirable in this discussion to note also that one of the critical factors in an investigation of the type described concerns holding of the various investigations to a cooperative program for accomplishment of a specific purpose. It might be easy to lay out a plan and to initiate a large number of investigations, including those in the fields of anthropology and ethnology together with a study of the physical and biological features of the environment, and yet accomplish little in the way of interpretation of the evolution of this people. A series of important monographs might then appear in geology, mineralogy, biology, physical anthropology, linguistics, social problems, religion, and other subjects, and yet these statements worked out in detail might fail to converge upon the problem of history and development of this civilization. One of the most difficult problems arises through need for presenting evidence of relation between those studies in the field of what we call the sciences, perhaps more specifically the natural sciences, and the problems which are recognized as human, as in sociology, art, and religion. The test comes finally in the result of conferences involving all of the elements, with a clear effort expressed by each group to contribute toward a synthetic study, rather than to secure from the mass of available information data which might be useful to specialists in their separate fields.

Tests of methods suggested for study of the Maya problem will

be found in concrete application of the various kinds of researches to special questions in which it is desirable to utilize several points of view. Although it has not yet been possible to obtain final results on many of the questions investigated, it is feasible to use several types of problems as illustration of the method. One of the questions in Maya history which has been most intensively discussed relates to the assumed practical disappearance of the Maya civilization as a living, progressive moment. This inquiry is sometimes confused with the question, "Why did the Maya disappear?" As has already been indicated, the Maya have not disappeared as a people or a race. The civilization as a vigorous, unified movement has, however, largely vanished, and is represented in the main by relics constituting the materials toward which the study of Maya history is directed.

Among many suggestions made regarding some of the major changes in Maya history there may be listed: (1) the possible influence of variation in climate upon development of the people and their civilization; (2) the possible influence of modification in physical and biological features of the region such as might materially affect the environment or setting of the people and their culture; (3) a suggestion has been presented by those who think of the possible influence of disease in destroying the people and in interrupting activities which produced the civilization; and (4) another possibility regarding which there has been discussion is presented by the idea that wars, either between divisions of the Maya group or between the Maya and outside peoples, may have been responsible for destruction of the civilization and of a considerable part of the population.

In considering the significance of suggestions such as those listed with reference to change or disappearance of the civilization, it is important to note that neither the Carnegie Institution, nor perhaps any other agency in this country, would find it possible to answer all of the questions which might be raised without arrangement for staff activities involving cooperative researches. The general plan of operation of the Carnegie Institution relative to study of the Maya has involved, first, the organization of a small but highly competent staff representing the active body in prosecution of researches in this field, and, second, bringing into cooperation representative investigators from various agencies for researches in which expert judgment

is needed for study of problems on which the Institution staff is neither highly trained nor widely experienced.

The possible effect of *change in climate* as a factor influencing migration, variation of population, and limitation in development of the civilization must receive careful consideration before it is either recognized as a probable factor or eliminated as without significance. As has been pointed out by Ellsworth Huntington in his volume on "The Climatic Factor, as Illustrated in Arid America," climatic changes of moderate extent might have marked effect on the geographic location of the Maya people, or upon the means of subsistence and therefore indirectly upon their health, or upon development of those cultural factors which underlie the growth of a civilization. Although much has been said regarding the climate of Middle America during the known period of Maya history, we have yet to determine with certainty the actual climatic variations which occurred within the region in that particular time. The answers to questions raised regarding this problem will be obtained only by the cooperation of a considerable group of students, among whom some of the most important will be those who, like Dr. A. E. Douglass, devote themselves to study of climatic variations and their influence both for the earth widely and in particular regions. The data required will involve studies of earth climate as derived from investigation in the fields of geology, palæontology, general biology, and certain special phases of meteorology. Even after the questions regarding climatic change have been answered, there will still remain need for study of the influence of such changes on life of the people.

The effect of *changes in physical features* of the Maya area would not improbably begin with study of the history of agriculture with particular reference to soil conservation. Fortunately, investigation of problems of this nature is now being advanced actively by many agencies of the federal and state governments in the United States, and by numerous research institutions in this and other countries, so that we shall soon be able to interpret the evidences of human influence on the soil, in this and in past periods, and the bearing of such changes upon human activities. There has been much discussion concerning the possibility of moderate changes in physical conditions such as might have been brought about by the influence of a particular system of agriculture on the site of the

ancient Maya city of Uaxactun, in the jungle of Peten, Guatemala. Extensive logwood swamps in the immediate vicinity of Uaxactun have been interpreted as possibly representing filled basins of shallow lakes. It has been thought that perhaps a system of agriculture used by the Maya tended to bring about the silting up of lakes, which would mean at the same time elimination of an important water supply and the loss of easy means for transportation. There is now under investigation the nature of the deposits in the shallow basins and the relation of these deposits to the soil covering of the surrounding region. Such a research as is suggested would involve a wide range of knowledge, including geology, soil erosion, the accumulation of deposits in shallow basins, and the relation of all of the data available to what we know of the history of agriculture as it is influenced by soil changes.

Another aspect of the discussion relating to change of physical features through the ages, as bearing upon the development of civilization and life of the Maya people, concerns the question of volcanic activity, both as a local, destructive factor and as a source of materials which might be distributed over wide areas. Catastrophic volcanic eruptions might cover areas of considerable extent with ashy material, not only destroying life and interfering with agriculture, but driving out the surviving remnants of the people. There has been much volcanic activity in parts of the Maya region; but we have yet to know the full story from the point of view of volcanology, geology, seismology, and allied aspects of science. We have also to learn the historical aspect of this story with special relation to the development of cultures of the Maya area. A large field for investigation is opened; the cooperation of careful workers from many fields of science will be needed, and there must be cooperation also of many representatives both from study of agriculture broadly and from the field of history in the sense of dating the sequence of eruptions and estimating the amount of damage done at particular stages of activity.

Another phase of the general problem of change in physical and biological features is one intimately related to development of what is known as *milpa* agriculture. This comprises many types of investigation in the field of agriculture, soil study, geology, and biology. The results of felling the forest followed by planting of corn giving a large crop the first year, a smaller crop in the second

year, and a much reduced yield in the third year have led to various interpretations of what occurs. According to one view, the soil is impoverished and the size of the crop diminishes rapidly. According to another view, the soil is not so distinctly impoverished, but development of weeds takes place rapidly after the first year, and the corn is crowded out largely by the more vigorous and rapidly growing weeds. The solution of this problem involves soil study from various angles, including the chemistry and impoverishment of soils. With these physical and chemical studies there must be careful investigation of relations among the elements of plant life in the region occupied.

The effects of *disease* through possible destruction of considerable sections of the Maya people, and as an influence tending to initiate migrations, we have yet to understand fully. One of the most interesting studies made on a problem in this field has been carried out through cooperation with the Harvard Medical School. The results have given us much of interest both with reference to life of the people today and as suggestion concerning their history in past periods. As these studies advance, and are fitted to what we know of other problems of human biology and of environment, they will unquestionably furnish much of importance concerning the history of the Maya people and their civilization.

Closely related to discussion of medical history of the Maya are certain researches which might be called anthropological or may be classed under nutrition. In this field would be the work of Dr. F. G. Benedict, of the Carnegie Institution of Washington Nutrition Laboratory, through which we have obtained extraordinarily valuable records concerning the physical condition of the people, including temperature, pulse, blood pressure, metabolism, and other important factors. With this work have been connected the studies of Dr. Morris Steggerda, who has examined practically the whole range of Maya foods, and has worked in cooperation with Dr. Benedict on the food values.

Still another phase of study relating to the physical condition of the people is that of Dr. T. J. Hill, of Western Reserve University, who has made careful study of dental features and conditions with special reference to the characteristics and history of the people.

If *war* be considered as a special factor influencing development of the Maya civilization, one may expect to obtain much of critical

importance as the record develops. But the story of these human activities will be one of the last to be read fully and clearly. Nevertheless the history of migration and conquest must be recognized as among the most important subjects for investigation in this field of research. The influence of wars between groups of the Maya we know to have been important, and also of great significance has been the conquest of Maya people by their neighbors. Through this factor there developed change of culture due to superimposing another type upon typical Maya characteristics, as is illustrated so well at the ancient city of Chichen Itza, in Yucatan.

The study of wars will involve problems of government, and also the careful examination of cultures and governments of contiguous countries. This is in itself a question of tremendous importance, making necessary the cooperation of many institutions.

Groups of studies which are closely related, but which are carried on under auspices in some measure separate, are found in the researches on *anthropology* conducted by specialists from the Department of Genetics of the Carnegie Institution, the Nutrition Laboratory of the Carnegie Institution, Harvard Medical School, and investigators from the Department of Anthropology of the University of Chicago. These studies collectively give an extremely interesting picture of the people as they are today, with some suggestion as to what might be considered racial characters extending back into remote centuries.

The studies in *language* carried on by Dr. Andrade, of the University of Chicago, and Mr. Tax, of Carnegie Institution, have brought together materials of great interest in the field of linguistics as a separate subject, but having also important bearing upon origin and migratory movements of the Maya. It has been shown, for example, that certain variations in language are related to geographical separation, and further studies may be expected to contribute much more of importance in this field. There is also under consideration the relation of language to present governmental organization and to social differentiation.

The *sociologic and economic features* of the Maya today have been the subject of extremely interesting and important investigations by Dr. Robert Redfield, of the University of Chicago, aided by Alfonso Villa, who at the beginning of Dr. Redfield's studies was the schoolmaster in one of several villages made the object of careful

research. The sociologic studies have included research intended to give a clear picture of at least one village of the Maya maintained in nearly primitive condition, and with this the examination of others which either are in direct contact with European civilization or illustrate intermediate stages. The story of the Maya of today in the sociologic and economic sense naturally relates itself closely to government, and is certain to give important information bearing upon organization and government of the Maya cities of ancient time. In this connection it is desirable to note that library and archive studies on the history of the Maya beginning with the date of the Spanish Conquest, and leading up to the present time, have contributed extremely valuable information bearing upon the sociologic, economic, and governmental characteristics of these people.

Referring again to the features of *natural environment*, it should be noted that work has been initiated in practically all fields of science touching this subject, beginning with geology and its information regarding building stones and water supply, and leading up through zoölogy, entomology, and botany to discussion of the life of the region considered by groups or units, rather than as entirely isolated elements. The method of approach in these researches is still new and it is important first of all to make sure that the picture is scientifically correct before attempting to utilize the data for interpretation of human history. But with due attention given to the fact that such investigations are for the purpose of securing information regarding the civilization, it is to be expected that much will be obtained.

Interesting illustration of a type of problem in this inquiry regarding the background of nature is found in the study of myriapods, or many-legged worms, and their relation to primeval forests. On the assumption that certain types of myriapods are found only in primeval forests, one might expect that mapping of myriapod groups would furnish information as to whether certain forested areas of the present are primeval, or whether they are new growth in areas once cut over, and perhaps used for agricultural purposes by the ancient Maya.

Considerable time will elapse before synthesis of the materials now being gathered can be expected to furnish a satisfactory picture of development of the Maya race and its civilization. It is, however, a matter of great importance to know the meaning of this

particular human experience, representing as it does one of a few great opportunities available for learning what human beings may do in growing up through a natural environment to what we call a high level of civilization. It is extremely desirable to have this aspect of human behavior worked through to a clear understanding regarding the capacity of human kind. Difficult as the problem is, it is sufficiently critical to warrant concentration of scientific effort from many directions upon interpretation of the data.

The value of the experience in Maya history is, of course, first of all important to the descendants of this people still living in the region. It is interesting to note the extent to which the Maya look upon their past as holding the story of many things which may be significant in their life today and in the future. Also we can be sure that the world as a whole would benefit greatly by knowing fully this fascinating history. In advancing the study it has been of much advantage to have for the people of Middle America cooperation in all aspects of science and of knowledge broadly, through all institutions and all countries from which effective contribution can come.

One aspect of the study of the Maya to which attention is also being given represents another peculiarly interesting relationship, namely, the contact of an original American civilization with a great civilization and culture from western Europe, as represented by the Spaniards. The contact of these two groups presents a very significant episode in the history of the world. Fortunately, there have been relatively few complicating elements or features to influence the subsequent interaction. This is an exceptional opportunity to learn something of the way in which different cultures affect each other through years of interaction.

Sometimes in contemplation of this whole story of the Maya I am impressed by the fact that the way in which certain aspects of culture grew in that country illustrates the manner of growth of knowledge and science. In many Maya buildings growth was by addition of layer upon layer, with different aspects of culture and art represented in different structural levels. So each stage is the foundation for a subsequent step, in which often there was advance or improvement. As we now see the picture, this is the method of advance of science, and broadly of knowledge. So, among the various reasons for this work, it seems desirable to

follow out the steps in development of this civilization to see what it may tell us regarding the nature of man as illustrated in the methods of his advance.

We may never obtain a sharp picture of human history, and perhaps we shall never have clear vision of those movements sometimes described as the steps in human evolution. But the message of the past collectively is of enormous importance to us, since actually we are in the main expressions of the past, with only a little that we contribute ourselves. At least we should know what the nature of past movements has been, in order to guide the future course of human development with some measure of intelligence.

Approximately a century ago, while on the voyage of the *Beagle*, Darwin saw a historical succession of life types in geological formations of South America, with a vision of its relation to the distribution of organisms. This picture ultimately translated itself into what we now call the general theory of life development, or evolution. I think often of the possibility that another notable day may come when to someone a new vision of the human story will appear, presented with such brilliant and artistic picturing that we shall see human history as offering for our inspection the most impressive spectacle in the field of knowledge.

BIOGRAPHY

THE GEOLOGICAL WORK OF PROFESSOR JOSEPH LE CONTE

PROFESSOR LE CONTE seems to have been first attracted to geological work by coming in contact with Dr. James Hall, the famous leader of the earlier geological school in this country. Up to the time of his first meeting with Hall, he had shown interest in geology, but was principally concerned with problems belonging in other branches of science. Though the first great stimulus to this work was received from Hall, his career in this field really began after his interests became identified with those of the University of California. The greater number of his contributions to geological science, both descriptive and philosophic, are based upon observations made on the Pacific Coast.

Professor Le Conte's work was in general the study of the greater problems in geology, rather than the description of isolated phenomena. He never mistook the geological symbol for the thing it represented, and he was never misled by anything foreign to the problem he sought to solve.

Though not generally considered a field geologist, he made extensive excursions to the regions of greatest interest on this coast. A considerable part of the Sierra range was explored by him, and his mountain study was carried north into Oregon and Washington. On his summer excursions he was not infrequently accompanied by students from his class in the University.

Although his greatest interest seems to have centered around problems concerning the relation of the greater physical changes, especially crustal movements, to the evolution of the organic world, he furnished important contributions to nearly all branches of geology. On the purely mineralogical or chemical side, we find him adding to our knowledge of metalliferous veins and he is generally recognized as one of the authorities on this subject. On the physical side he interested himself in the carrying power of water, and in the exact study of earthquake waves. In palaeonto-

University of California Magazine, vol. 7, p. 214, September 1901.

logical work his description and discussion of the famous Carson footprints, which was actually the first on that subject to be completed, is a truly remarkable piece of investigation. Much of his most important work was in the field of general inorganic geology. Here he contributed largely to the literature on the origin and formation of mountains, the evolution of continental masses, the permanence of continents and ocean basins, movements of the earth's crust and their causes, the great lava flood of the northwest, Mono volcanoes, and the glacial geology of the Sierras. He was also an active worker in historical geology, and some of his latest publications on critical periods in the earth's history, and the Sierran (Ozarkian) epoch, open practically new territory for research.

The work which Professor Le Conte accomplished in geology shows throughout a conception of relations of the various branches of natural science to each other such as has been possessed by but few. To the close of his life he kept himself perfectly informed on all the important work being done in the natural history sciences, and owing to his wide field of vision he was frequently able to determine at a glance the proper relation of things, which others, limited to a narrow field, could not possibly discern. This is shown very frequently in his combination of the good points of several quite different theories bearing on the same subject. Many of his contributions, more especially those on critical periods in the earth's history, show just such a grasp of the whole subject of geological and biological sciences. In this work he called attention, as had never been done before, to the effect of complex physical changes such as critical movements and modifications of climate on the progress of organic evolution.

Through all of his contributions to historical geology, there runs as the central idea the theory of organic evolution. The fossil forms preserved to us from the past periods were not considered by him simply as curiosities which were interesting because they happened to appear strange to us, but rather as the sacred remains left by a countless succession of generations which has passed to us, along an unbroken chain, the principle or germ of life. Probably no other writer in the field of historical geology has made such successful use of the evolutionary or narrative style of the treatment of the subject. Though Professor Le Conte ascribes the

first use of this method to Dana, it is probably true that his own work had great influence in finally bringing Dana to the point where he could unreservedly accept evolution as based on actual historical succession. In his later lectures and discussions of the theory of evolution, to which he has contributed so much, he placed the strongest emphasis on what *has been* rather than on what *might be.*

In his intercourse with other scientific men Professor Le Conte was always helpful, sympathetic and appreciative. He always gave freely of his store of knowledge in assisting others to solve problems which refused to yield to them. Though he engaged in many discussions with those whose views differed from his own, he made no enemies. Always respecting others' opinions, whether he accepted them or not, he was ever held in the highest respect and esteem by geologists of all lands. In recognition of his services to geological science, Professor Le Conte was honored by election to the highest positions which the science associations of this country could confer. He served as President of the American Geological Society, and of the American Association for the Advancement of Science, and had been Vice-President of the International Geological Congress.

As far-reaching and as lasting as Professor Le Conte's influence may be seen to be among the men of his profession, it will probably not exceed that which he has exerted on the world at large in the capacity of instructor. In his own classroom at the University of California during more than thirty years, he presented to interested audiences the best that there is in his subject. Such was his power of explanation and description in the lecture room that the most difficult problem seemed absolutely to melt away, and often hearing him on such subjects students have been known to state that an explanation seemed hardly necessary, as the matter was so easily understood. Through the medium of his text-book, "The Elements of Geology," he has covered a vastly larger field than could be reached in his lectures. Probably no college text-book in science has been more widely used in this country than "The Elements." Certainly there are none which present in a simpler or more attractive form the elements of any science. His treatment of the subject was, when his book first appeared, in many respects

essentially new, and almost for the first time it was made clear that geological history is only the earlier part of history in general.

With the passing of Professor Le Conte, geologists lose a great contributor and leader, and the world loses a great teacher. Others may arise who in scientific attainment in this particular branch of research will perhaps stand in the same rank with him, but it will be long before we find again in one man that combination of qualities which has made Professor Le Conte not only one of the most successful gatherers of knowledge, but also one of the foremost teachers.

DOCTOR WALCOTT AS A PALEONTOLOGIST, AND HIS RELATIONS WITH THE CARNEGIE INSTITUTION OF WASHINGTON

Of many relationships to Doctor Walcott those which I shall cherish most in memory are the two concerning which I am privileged to speak on this occasion. One relates to the closely binding tie of common interest in a fundamental subject of research to which his life and mine have been in part devoted, namely, the real significance of the paleontological or life story. The other concerns one expression of Doctor Walcott's interest in creative work, as illustrated in his twenty-five years of service as an organizer and leader in the program of a research agency with which I am connected, that is, the Carnegie Institution of Washington.

It was a mutual interest in the importance of paleontological problems that brought about my first conference with Doctor Walcott. The discussion related to the future of research on the history of life in America. It was by reason of our common interest in application of research results for the benefit of the people that I worked with Doctor Walcott on many enterprises of national scope. It was through a realization in my mind, as in Doctor Walcott's, that the lesson of evolution of the living world suggests the importance of continuing investigational or creative effort, that I came into continuing touch with administration of research problems.

Doctor Walcott's personal contact with research questions, his effective practical grasp of methods of investigation, and his recognition of the meaning of creative effort in terms of human service, made him a critical figure in the initial planning, as through all stages of organization and development, of the Carnegie Institution. The statement in the charter of the Institution defining its pur-

Address at memorial meeting for Charles Doolittle Walcott, January 24, 1928. "Charles Doolittle Walcott, Secretary of the Smithsonian Institution 1907–1927," *Smithsonian Miscellaneous Collections*, vol. 80, no. 12 (Smithsonian Publication 2964), pp. 5–9, May 12, 1928.

poses, which reads—"to encourage in the broadest and most liberal manner investigation, research, and discovery, and the application of knowledge to the improvement of mankind"—expressed the specific interest of Doctor Walcott in this agency.

As one of the original incorporators and a member of the first Board of Trustees of the Carnegie Institution, Doctor Walcott served continuously from the time of organization until his death. He was its first Secretary, was a member and Chairman of the Executive Committee, and Vice-Chairman of the Board. As a member resident in Washington his advice and counsel played a large part throughout the twenty-five years of his membership. His wide contacts with government departments, universities, and research agencies of all types, his exceptional range of interest in the various fields of science gave him a point of view and a quality of judgment of inestimable value. The Institution owes much of its accomplishment to his conscientious adherence to a program of high ideals based upon practical, intensive study of facts.

I know that I express the wish of the trustees, directors, and members of the staff of the Carnegie Institution in voicing on this occasion our heartfelt gratitude for Doctor Walcott's contribution in the building of many departments, as Mount Wilson Observatory, Geophysical Laboratory, and others, and his assistance and advice on nearly all of our greater projects.

The major research efforts of Doctor Walcott's life were directed toward the earlier portion of the historical record of the earth. Though he contributed much toward our understanding of general geological phenomena, his interest centered upon the earlier chapters of the history of life.

One source of Doctor Walcott's power in research lay in his never losing sight of the fact that there is really only *one* history, which includes the record of physical phenomena and the relation of the story of life to the sequence of events in their environment. Whether he happened to be concerned with determining the sequence of strata necessary as the guide to succession of events in time, or with interpretation of great gaps or erosional intervals between such series, or with details of structure in any of the many groups of trilobites or other invertebrate animals which he loved to study, there was always before him the idea that the facts fitted into *one* scheme of interlocking events in earth history.

As another aspect of the attitude toward his subject which gave Doctor Walcott exceptional power in furtherance of the study of his subject, one may note that he had at the same time a reputation as a collector with rare penetration of vision, and as a generalizer with almost superhuman judgment as to where in the geological or geographical scheme of things new data would have exceptional interpretive value. The relation between these two characteristics expresses in a manner the breadth of his view and the keenness of his perception. He found types of life new to science in unexpected places, not because of luck or *mere* persistence. His success was partly due to exceptional keenness and alertness, but largely to his having a picture of the kind of thing that it would be important to find and of the place where if found, it would be especially significant.

This is not the time or place to discuss in detail the contributions Doctor Walcott made to the study of the early life of the earth, as to the structure of ancient animals, their biological classification, their faunal grouping, or their succession in time. It is, however, important to note that in all of these aspects of the problem his accomplishments belong in the first rank of the world's researches. In studies ranging from a fundamental investigation of structure and habits of many groups of trilobites and other crustaceans, of the mollusca and the mollusk-like brachiopods, the early coral-like forms, the simple protozoa, and the bacteria, his work was of the pathfinding type.

In the whole range of researches of the world Doctor Walcott's studies of the earliest known assemblages of life, and his working out of the facts relating to the earliest traces of life upon the earth, constitutes the most important single contribution. It marks his greatest achievement in contribution to knowledge and to constructive or interpretative thought.

In his work on the "Origin of Species," Charles Darwin gave large value to certain evidence against his theory of evolution which is presented by the earlier part of the geological record of life. With that perfectly balanced judgment which characterized his work, Darwin discussed the fact that a full representation of highly developed and widely differentiated life beginning in the formations known as the Cambrian at the bottom of the geological column, did not give the picture of beginnings of life that his theory of evolution seemed to require. Darwin considered (to quote his

words) that "The difficulty of assigning any good reason for the absence of vast piles of strata rich in fossils beneath the Cambrian is very great. . . . The case at present must remain inexplicable, and may be truly urged as a valid argument against the views here entertained." He believed, however, that many existing factors opened the way for satisfactory interpretation of the situation and that it would (to quote him) "be about as rash to dogmatize on the succession of organic forms as it would be for a naturalist to land for five minutes on a barren point in Australia, and then to discuss the number and range of its productions."

It was this field which Darwin considered so difficult and so important, extending from the better understood ancient or "Paleozoic" rocks through to the lowest known strata, in which Doctor Walcott planned his attack and made his outstanding contribution. His full description and interpretation of the earliest faunas, and his suggestions as to the significance of the preceding record, or absence of record, have not only given a clear understanding of what we see, but have led us to appreciate as well the true significance of those portions of the record for which we have as yet no complete interpretation.

Doctor Walcott recognized that, of all the ideas in the field of knowledge, there is none more important than the suggestion that the life world as we know it in paleontological history has tended definitely to build itself forward from age to age. He realized that this principle furnishes one of the essential elements for belief in the possibility of continuing progress in the living world as a whole including man—a belief or faith which is clearly an indispensable ingredient of human happiness whether it be expressed in our philosophy, in our religion, or in the affairs of everyday life.

But Doctor Walcott did not assume that science can present a complete explanation of everything that is, or was, or that will be. He saw the long story spread before us, as we trace the intricate and fragmentary records through the rocks. He understood its meaning to us, as have few students whose privilege it has been to walk back along the path of history. On the basis of his experience he visualized more clearly than Darwin the two terminal fields of our historical series—the future, of which we can judge mainly by the past, and at the other end the seemingly abrupt initiation of the living world. His effort was consciously directed toward attainment of an interpretation of the beginning of our record as we find

it, and on the basis of facts and reason, rather than upon purely mystical construction of a sequence without data.

His work, together with that of the many others who have helped in the initial unravelling of the tangled threads, has shown in large measure the correctness of Darwin's assumption that while the long record from present back to Cambrian and earlier time serves to define certain general principles of primary importance, we are not yet permitted to see the whole of the panorama. But this situation need not today serve as an argument against the idea of organic development which Darwin discussed with such marvelous honesty in presentation of argument. It means only that time is vastly longer than Darwin saw it, and from the wreckage of the most ancient stages of the world, the changing story may be hard to read or may perhaps have been erased completely from the book.

It is not an uncommon belief that the fortunes and achievement of outstanding characters in history depend in large measure upon chance. The incident which seems to turn the trend of life, as we see it in the history of a great character, seems to the purposeless individual an accident which provides a way not possible to others. But frequently the thing which seems so easily, and yet so oddly to open the door, merely represents one of many avenues which might have led to the same goal. The fact that a particular individual has used it to advantage is likely to be dependent in larger measure upon interests or attitude of mind, than it is upon the particular opportunity. Had he perhaps waited, with the stimulus of his pressing interest he might have found another way much easier.

Perhaps it is merely in support of a desire to feel that the universe *is* dependable, and that directed human effort *may be* fruitful, that we take the view that life can be *guided* and *determined*, rather than be the result of fortuitous influences.

The achievement of Doctor Walcott's researches in the unbelievably difficult field which he chose indicates that luck comes to the man with penetrating vision and unceasing industry. The major contributions which Doctor Walcott made to the story of earth history, bring a deepening of our faith that in the sea of time, behind the froth and broken waves that may deceive us, there is a moving tide—controlled by law—that we begin to understand.

THOMAS CHROWDER CHAMBERLIN

CHAMBERLIN, THOMAS CHROWDER (Sept. 25, 1843–Nov. 15, 1928), one of the outstanding contributors to constructive thinking in the geologic sciences of the past half-century, was born in Mattoon, Ill., the son of the Rev. John Chamberlin, a Methodist minister, and of Cecilia (Gill) Chamberlin. When he was three years old the family moved to Wisconsin where he grew to manhood. In 1866 he received the degree of A.B. at Beloit College, and for the next two years was principal of the high school at Delevan, Wis.; meanwhile, in 1867, he was married to Alma Isabel Wilson. He was a graduate student at the University of Michigan, 1868–69; professor of natural sciences at the State Normal School, Whitewater, Wis., 1870–72; professor of geology at Beloit, 1873–82. It was while he was at the latter institution that his really important work began. The fact that he resided in a region of notable glacial deposits was of great importance in the development of his career as a student of earth history. The climatic conditions in past ages, as revealed by traces of ancient glaciers, contrasted sharply with the situation obtaining to-day, and presented a series of questions for which no fully adequate answer had been obtained. His study naturally directed itself, first, to intensive examination of the material remains upon which must be based any research into the physical or climatic conditions through which these relics had been produced. Armed with the evidence secured by his investigations and stimulated by the continually increasing complexity of the problem, he extended his studies to consideration of earth climates through the known range of geological time.

In 1878 he made a special study of the glaciers of Switzerland. By 1883 he was recognized the leading American glacialist (H. L. Fairchild, *post*, p. 611). During these years he was also the assistant state geologist of Wisconsin, 1873–76, and the chief geologist,

Dictionary of American Biography, vol. 3, pp. 600–601. New York: Charles Scribner's Sons, 1929.

1877–82. Here he had the task of publishing the results of a geological survey of the whole state, made by himself and his associates, in *The Geology of Wisconsin* (4 vols., 1873–82). Volume I contained his summary of the geological history of Wisconsin, beginning with a discussion of the origin of the earth. The work attracted so much attention that a Division of Glacial Geology, of which he was appointed chief, was established in the United States Geological Survey at Washington, D. C., in 1882. He was also professor of geology in Columbian University, Washington, from 1885 to 1887. In the latter year he was called to succeed John Bascom [*q.v.*], in the presidency of the University of Wisconsin. His incumbency fell in the period when the college of liberal arts developed by his predecessor was beginning to expand into the later university. Chamberlin foresaw the future clearly and outlined the policy to be pursued. In his initial year, through the foundation of eight university fellowships, he took the first formal step toward the encouragement of graduate study; he improved the law school; and in his fifth and last year he inaugurated a university extension movement.

In 1892 Chamberlin was appointed head of the department of geology and director of the Walker Museum in the new University of Chicago. Here he remained until his death, becoming professor emeritus in 1919. In 1893 he founded the *Journal of Geology* of which he was editor-in-chief until 1922 when he became senior editor. In 1894 he accompanied the Peary Relief Expedition. In 1897 he published his first non-glacial paper, "A Group of Hypotheses Bearing on Climatic Changes," which contained the germ of his later "planetesimal hypothesis." In 1898 he outlined in "The Ulterior Basis of Time Divisions and the Classification of Geologic History" a line of approach which was to culminate in "Diastrophism as the Ultimate Basis of Correlation" (1909) and "Diastrophism and the Formative Processes" (1913, 1914, 1918). He discussed the nebular hypothesis in "An Attempt to Test the Nebular Hypothesis by the Relations of Masses and Momenta" (1900). In 1906 he published his *General Treatise on Geology*, written in collaboration with R. D. Salisbury. In 1916 his epoch-making volume, *The Origin of the Earth*, appeared, and in 1928 his last work, *The Two Solar Families*.

"Chamberlin was regarded in the profession as without question

the ranking geologist of America" (C. K. Leith, in *Wisconsin Alumni Magazine*, Dec. 1928). His outstanding contributions are generally recognized as threefold: first, his detailed researches on glacial phenomena as illustrated in the relics of glaciation so widely spread through the northern United States; second, his investigations of geological climates, arising naturally out of the study of exceptional climatic conditions in the glacial period; third, the contribution to cosmic geology represented in his "planetesimal hypothesis" of the origin of the earth.

The trend of Chamberlin's researches into the geological history of the more remote ages made necessary his inquiry not only into the evolution of climates, but into questions concerning the origin of the atmosphere itself. In examination of the variation in atmospheric conditions the proportion of carbonic acid in the atmosphere appeared a critical factor. Investigation of these particular phenomena reached beyond the study of the origin of the earth climates, and involved groups of inferences relating to the development of life under varying conditions in past periods, and the possibility of linking a wide range of diverse elements in earth history through their relation to atmospheric conditions. The study of climatic changes and the origin of the atmosphere carried Chamberlin ultimately into discussion of the dynamics of the earth, with problems relating to the nature and degree of regularity of earth movements in past time. In another direction it led directly to a consideration of the origin of the earth, which could be discussed only in association with problems relating to the development of the solar system.

Always characterized by exceptional broadmindedness, and by recognition of the need for utilization of all available materials and application of every possible hypothesis for a study of each specific case, Chamberlin illustrated to an extraordinary degree the development of these qualities in his study of problems relating to the origin of the earth. Drawing into cooperation with him a wide range of investigational efforts in the field of mathematics and astronomy, he brought practically the whole of organized study in cosmic physics to bear upon this interesting problem. In connection with these researches, special mention should be made of his long association with Forest R. Moulton, whose expression of the problem in terms of mathematics and astronomy supplemented in an ex-

tremely important manner the constructive thinking of Chamberlin.

It was clear that the widely-recognized hypotheses represented by that of Laplace were not competent to account for the development of the earth and other planets, and effort was made to secure an interpretation which would fit the requirements of physics. The result was the theory that the earth and the planets owed their birth to the approach of another sun or star bringing about the partial disruption of the sun, and the expulsion of a great mass from which ultimately the earth was derived. This evolution was defined as by way of a swarm of minute, solid particles, the "planetesimals," swinging in orbits about the sun, and ultimately gathering to build the earth. Checked from every point of view, this became the "planetesimal hypothesis" of the earth's origin.

[H. L. Fairchild, "Thos. Chrowder Chamberlin—Teacher, Administrator, Geologist, Philosopher," *Science*, LXVIII, 610 ff., Dec. 21, 1928; Chas. Schuchert in *Am. Jour. Science*, ser. V, no. 98, vol. XVII, pp. 194–96, Feb. 1929; *Univ. Record* (Chicago), Jan. 1929; *Geographical Rev.*, Jan. 1929; *Sci. Mo.*, Jan. 1929; *Jour. Washington Acad. Science*, XVIII, 564, Dec. 4, 1928; *Bull. Geol. Soc. of America*, XXXVIII, 6–7, Mar. 1927; R. G. Thwaites, *The Univ. of Wisconsin* (1900), pp. 129–40; G. F. A. Pyre, *Wisconsin* (1920).]

FRANK SLATER DAGGETT

UNDER the directorship of Frank S. Daggett, the Museum of History, Science and Art of Los Angeles has come to exert an important influence in science and education in Southern California. The collections representing the history of California and the southwest, and especially the splendid representation of the extinct life of California secured from the asphalt deposits of Rancho La Brea, have made the institution the object of frequent visits by large numbers of residents of California and by travellers from the east. The rapid development of the museum, the excellent organization of its collections, and the maintenance of a high standard of efficiency throughout the institution were in a very large measure due to the untiring effort of Mr. Daggett. Interesting and valuable exhibits representing living birds, mammals, and molluscs of Southern California were assembled under Mr. Daggett's direction, but by far the most important collection was that representing the extinct fauna secured in the extraordinary asphalt deposits at Rancho La Brea on the western border of the city.

Born at Norwalk, Ohio, in January 30, 1855, Mr. Daggett was for the greater part of his life engaged in commercial pursuits. He was a successful grain merchant at Duluth, Minnesota, from 1885 to 1894, and was a member of the Board of Trade of Chicago from 1904 to 1911. He was always deeply interested in natural history and from his early boyhood was engaged in the study of insects and birds.

His collection of Coleoptera numbered two thousand species and his bird collections contained over eight thousand specimens. Although he published little of a technical nature his interest in natural history subjects was a continued inspiration to many who were professionally engaged in scientific pursuits, and his influence in the advance of natural history of the Pacific Coast has been a factor of much importance.

Science, n. s., vol. 52, no. 1341, p. 242, September 10, 1920.

Mr. Daggett became the director of the Museum of History, Science and Art in 1911. At the time of his assuming the office, the building was finished, but contained no exhibits and no staff appointments had been made. Among the first tasks taken up was the securing of privileges for collecting in the Pleistocene deposits at Rancho La Brea. The excavations were carried on with the most extreme care and with all advice that could be obtained from those especially interested in the scientific study of the deposits. With the utmost precautions the great series of specimens unearthed was cleaned, prepared for study, and marked as to location in the beds. At no stage in the handling of this great collection was anything omitted which might have helped to make the material more useful to the student of future years. Along with its many other contributions to science the Rancho La Brea collection of the Museum of History, Science and Art must always remain as a monument to the scientific interest and administrative skill of Mr. Daggett.

It was the writer's privilege to make the acquaintance of Mr. Daggett at the time of his first interest in the deposits at Rancho La Brea, and to cooperate with him through the whole work of the excavation and preparation of these collections. In these years of close cooperation and friendship he proved himself a man of the highest ideals and finest purposes in development of all that is most fundamental and significant in the phases of natural science with which he came in contact. Although Mr. Daggett's name will not be known in future years by length of publication lists or by species described, there must be given to him a full measure for very significant constructive work done with much interest, with keen insight, and with an effectiveness which is rarely equalled.

GENERAL ADDRESSES

REMARKS OF CHAIRMAN IN INTRODUCING SPEAKERS, COMMONWEALTH CLUB MEETING ON SCIENTIFIC RESEARCH

In speaking at this time of scientific business organization and business organization of science, it seems almost like wasting the time of the Commonwealth Club to ask you to give an hour or two to the relation of science to industrial progress. Yet there is a wide gap between what we call the fundamentals of science and the application of results of scientific investigation and research. Everyone realizes the value of science as soon as it can be applied, but no one fully realizes the value of scientific investigation before it has been applied. Yet we know that the great beaten paths over which we travel are paths which were first worked out for us without the idea that they were to be of use, and without knowledge of the directions in which they were to lead.

While the human mind is always inquiring with reference to things new, we are naturally more or less conservative; and while we consider that in the past there has been a steady progress in science, when we look to the future we are more or less pessimistic about what is coming out of the things with which science is interested at the present time. This has always been the situation, and that is one of the reasons why we are bringing this subject before you tonight. That is to say, the things which the scientist does that are not of immediate practical value are very often considered of no particular importance to the community, even in the long run. This is a natural position for us to take, because we are necessarily practical, as human beings who must make a living, and we consider the thing which is not of immediate importance as set in a secondary position.

But tonight I think it will be shown to you that we must cultivate all investigation, in whatever direction it leads, provided the investi-

In preliminary report of the Committee on Scientific and Industrial Research, Commonwealth Club of California, March 14, 1917. "Scientific Research," *Transactions of the Commonwealth Club of California*, vol. 12, no. 2, pp. 69–70, 80, 83–84, 90, 96, 104, 107, 111, April 1917.

gation tends to give to us some addition to the field of knowledge, something that is added to the border of the known. We all, I believe, are willing to admit that the field of the unknown is vastly larger than the field of the known. Therefore, should we not encourage those who go as pioneers into that unknown region and bring back the things which we are to use in the future?

I suppose if I were to say that some of my friends have a feeling that the time is not far distant when we shall be able to make anything we wish out of any substance that happens to be at hand, you would say that is stretching the ability of the scientist. But we know that many men engaged in physical and chemical work have the idea that, having analyzed matter down to a few fundamental materials, the time is not very far distant when we shall be able to change one substance into another substance—in other words, transmute materials—so that any kind of matter may be made over into another kind of matter. I do not say that is very close to us in years, but it looks to many scientists as a perfectly feasible thing—that we may make from any substance any other substance. I imagine that this discovery will not be made by a man who is working upon this particular problem; it may be worked out by someone who is aiming at an entirely different mark. It will, however, be worked out by a scientist of broad vision, who understands the fundamentals of physical and chemical research methods. I suppose that if anyone were to discover a method by which we could turn lead into gold, or wood into gold, the economists would expect this to upset the whole foundation of economic organization. It may be that the good Lord is holding off the time of this discovery until we have a foundation other than the cost of gold.

I only suggest this discovery of the process of transmutation of elements as an example of scientific investigation well within the visible limits of progress. This discovery might result in something of enormous consequence to the world at large.

The aim of science is to discover new principles and apply them in all directions. What we are attempting to do in the work of our committee is to tie the fundamental scientific work, which has as its aim the understanding and organization of nature, to the applications for the needs of man in all possible directions. We can cover only a few of the principles and a few of the applications tonight, but

they will be covered well. The first address will be given by Dr. Campbell. I do not need to introduce him. I am always pleased to hear Dr. Campbell, and when he gave one of his last important addresses I went as far as New York to hear him. I am sure you would be willing to go just as far if you could hear as good an address as I heard from him in New York. It is with great pleasure that I now present Dr. Campbell to you.

It is generally said that most of the difficulties occurring among men in the world owe their origin to the fact that we are not able to bring a number of people to see the same thing in the same way. Universities are said to exist for the purpose of giving the broadest and deepest possible view of things as they are, as they have been, and as they are to be. I assume that it is the business of university professors to hold up to the eyes of their students the lens of knowledge so that they may be rid of their intellectual or mental astigmatism and see things in their true position. I assume that it is the business of a faculty to give the students that courage of conviction of the man who sees things as they are and knows that things will stay put. Most of us when we are cowards are cowardly because of uncertainty. The man who goes out from the university should have the clear vision, and by reason of this the strength of conviction, that will enable him to take the initiative.

Stanford University has this clear vision and stands for it. It is a pleasure to us to have with us its president, to talk to us concerning results of research and their application as he may see fit to describe them—President Wilbur.

We look back only a few years to the time when we thought of the farmer as being the exact opposite of the scientist. At the present moment we find the agricultural schools or colleges of this country among the most highly organized scientific institutions; and there is no institution, so far as I know, that is better organized or that shows better the result of combination of research and its application than the agricultural department of the University of California, the Dean of which is to talk to us further upon the subject of "Research and Its Application."

I think I ought to make an explanation to the Commonwealth Club; I went to New York to hear Dr. Campbell, I spent twenty-five cents on a long-distance telephone message to Dr. Wilbur, and Dean Hunt said I had spent nothing in securing his address. Judging from the curve of investment, it might begin to look as if the men presenting the next addresses had paid me something for the privilege of speaking. Of course, the members following me will not say anything about this matter. I only wish to say that I have not received anything from them. If it should be proved that anything has been paid to me, I am going to dedicate that fund to science. I also wish to remark that Dr. Wilbur and Dean Hunt did not tell me they were going to talk in New York, but if I have the opportunity I am going just as far as I can to hear them.

The members of the committee have worked hard in bringing together a number of reports which are to be published in full in the proceedings. It is not possible to present full reports here tonight, but five members have been asked to present brief statements of results that have come from their work.

Dr. Whipple represents a very important kind of research work, in medicine, about which he is going to tell you; I take pleasure in presenting him to you.

I sometimes think that the field for investigation about which the average man knows least is the sea. We live on the borders of a great sea or a great ocean which extends out for thousands of miles, and down for thousands of feet. Some few of us may perhaps go out upon it, may dive down for a few feet, and we may open our eyes and look around and see something of it; but most of us know practically nothing about the almost fathomless depths of the ocean, and the life in it. I am going to ask Dr. Evermann, a member of the committee, to say something about the fishery problem, in such time as is available to us this evening.

The relations between science and its applications in engineering are so numerous that we might well have many meetings to discuss

this aspect of the problem. We have three brief reports to present this evening, the first of which will be by Mr. Bernard Bienenfeld, on the relation of research to industrial development.

Mr. Grunsky needs no introduction before the Commonwealth Club.

The last brief report is that by Professor Hyde.

REMARKS OF CHAIRMAN IN INTRODUCING SPEAKERS, COMMONWEALTH CLUB MEETING ON WAR TIME ADVANCES IN SCIENCE

This is unexpected, but it is always a pleasure to speak to the Commonwealth Club, particularly when I can do so through two such good men as Dr. Durand and Dr. Campbell. It is with much pleasure that I recall the meetings to which the President has referred, at which we had those splendid papers by Dr. Campbell and his associates, and I also remember very well the meeting which followed in the fall. I believe that the first meeting was about two weeks before war was declared. The second meeting occurred after the country had begun to take its stride, the many kinds of organizations which had sprung up had gotten into operation, and I think I remember that at that meeting we presented the first report from a state committee on scientific research, which we hoped would do some things of interest. Since this last meeting it has been of much interest to me to note that practically all the men appointed on the committees in California for state work, in one way or another volunteered into national work. The committees were pulled apart and the men were scattered over the country.

So far as the scientific aspect of our interest is concerned, I am glad to say that what they had to do seemed to be something the people wanted to have done. I think many men not of the academic type are inclined to think that what the professor has to do is what nobody else is concerned with, and that many of these men of the academic mind found that the things they had to do were things that people wanted all the time.

Now that the war is over we have come to look over the field and to see what has been accomplished, and I rather feel that we are tonight before a group of men who will naturally judge us on what we have done; and to some extent it is necessary that we state here, as I believe the President expressed it to me sometime ago,

In report of the Committee on Scientific Research, Commonwealth Club of California, September 25, 1919. "War Time Advances in Science," *Transactions of the Commonwealth Club of California*, vol. 14, no. 9, pp. 380–381, 393–394, October 1919.

what it is we did on all this that we talked of before the war and at the beginning of the war; in other words, did science accomplish something or did it simply talk and talk as it seemed to do up to the period preceding this conflict?

I have no doubt myself as to what it accomplished, and I thought it best to have this represented to you through two men who have been concerned particularly with certain aspects of this scientific work. Dr. Durand was interested especially with those most important applications of physics, chemistry, and allied subjects through engineering, and in engineering we had the most important application of science during the period of the war. Dr. Campbell was interested in the application of other kinds, and the acme of his work was reached in his representing the United States in a conference held by the governments of the allied nations in Europe some months ago for the purpose of organizing the world on a scientific basis, in order to put into effect the many things which had been planned, in order to make use of the many things which had been discovered during the period of the war.

It is a pleasure to introduce to you first Dr. W. F. Durand of Stanford University, I think known to all of you, one of the few engineers in the United States who has had the recognition of election to the National Academy. Dr. Durand was during the early part of the war the chairman of the National Advisory Committee on Aeronautics, which performed exceedingly important service during the whole of the war. Later Dr. Durand was the scientific attaché of the National Research Council at the American Embassy in Paris, where he represented the scientific work of this country. Dr. Durand has been often mentioned to me as the most scientifically minded engineer in America, and I know that is correct. It is a great pleasure for me to introduce him to you to speak on "Contributions of Scientific Research to Engineering and its Application During the War."

Dr. Durand has helped me to introduce Dr. Campbell. He has told you of the work which he was doing during the war as a representative of our National Research organization representing us in France and helping to bring together the scientific bodies of the allied governments, so that all the information available might be

made to focus on the places where we needed work done. Just as we had an office in Paris under the direction of Dr. Durand, we had another in England and another in Rome, and this group of organizations was known as the Research Information Division of the National Research Council. We were very fortunate in America in that we had close relation to the important agencies of the United States Government concerned with scientific information which might be brought to bear on the problems of the war. As one illustration of this relationship, the committee in Washington directing the Research Information Division consisted of the Chairman of the Research Council, the head of the division of Military Intelligence of the Army and the head of Naval Intelligence.

We saw very early that not much could be done in the part which science played in the war unless we could secure that kind of an organization which would bring every fact that could be found to bear upon the problems in hand. Dr. Durand says it is possible to make an engine like the "Liberty" by having one part made in Los Angeles, one in San Francisco, one in Portland, one in Chicago, one in New York, and other parts elsewhere, and these pieces can be brought together and the engine will work; in other words, America has learned to do things this way while Europe has not learned to handle quantity production so that many parts will fit together and make units. What was done in constructing the Liberty engine is in some measure what we attempted to accomplish in scientific investigation. We saw that scientific knowledge represented such a tremendous field that you cannot get any one person or small group able to see over the whole range of scientific wisdom. We must have the co-operation of a great number of groups of men. That means that we need to have organization of science. Very fortunately the scientists saw this, and one of the men who was most instrumental in initiating organization and putting the west coast in the lead was Dr. Campbell. Before the war came Dr. Campbell was the leading spirit of the Pacific Division of the American Association for the Advancement of Science. Here he welded together the best organized division which we have in the United States. He was not satisfied with that, but helped also to organize the whole American Association and became then the President of that organization. When the war came, he helped to bring

in every one of these groups for useful work. Later, when it became necessary to organize science in the international sense, Dr. Campbell lent his assistance, and Dr. Campbell headed the American delegation to the international conferences held in Brussels last July. To many of us it seems that out of this organization there is coming something which might foreshadow government in the broader sense. In the field of science we have organized a kind of League of Nations. It was not on a large scale; but it has been organized so that it works.

Dr. Campbell will tell you, from his point of view, how this organization in Brussels was carried forward and what it stands for at the present moment.

REMARKS ON OUR SISTER SOCIETIES, AMERICAN PHILOSOPHICAL SOCIETY BICENTENARY

THE American Philosophical Society occupies a position of unusual interest among organizations of America devoted to development and interpretation of knowledge. The linking of those aspects of science which touch accumulation and interpretation of facts to the group of problems concerning human interests is one of the characteristic features of the Society. This agency is concerned not alone with ideas, which in another form of expression may be called knowledge. Its organization and general programme represent also the statement and interpretation of ideals, which may be described also as wisdom.

From the time of its origin, the Philosophical Society has concerned itself with the extremely interesting problem of finding human application of science and, at the same time, attempting to obtain scientific foundation for study of characteristics peculiar to man. It attempts in its organization to bring these various subjects into their true relation to each other. The Society recognizes that safety of mankind lies not alone in discovery of impersonal laws and attempts to secure their enforcement. It realizes that the ultimate goal in human organization must be attainment of a type of relation in which law-understanding and acceptance will replace mere law-recognition and enforcement.

Through the ages, movements tending toward establishment of government and control of human relations have had two main objectives; on the one hand, the privileges of liberty; on the other hand, exercise of power. Both factors are essential, both involve great dangers. Extent of the danger widens with limitation of either wisdom or knowledge. In organization of human thought religion has been in large measure based upon recognition of power. Philosophy has represented search for knowledge and the sources of power. Science has been the great accumulator of facts. It now becomes an interpreter, fitting itself closely to philosophy and religion, and serving the needs of government.

Address at the bicentenary banquet of the American Philosophical Society, April 30, 1927. *Proceedings of the American Philosophical Society*, Bicentenary Number, vol. 66, pp. 737–738, 1927.

In all evolutionary or developmental processes concerning life the principle of coöperation has come to be essential. In development of the organism it is involved in that differentiation making possible the vastly complicated individual with multifarious functions. In society it is at the foundation of those principles which guarantee to us the right of individual achievement limited only by recognition of comparable opportunity for others.

The principle of coöperation in the universe of human beings involves not merely all men in all places, but all men at all times. It recognizes not alone the inter-locking interests of individuals at a given moment, but includes as well the continuity of effort extended through time. It guarantees to the past the value of its contribution. It safeguards the joys of accomplishment of the present. It lays for the future those foundations upon which further building must rest.

The intertwining of philosophic and humanistic interests in the Philosophical Society helps not merely in deepening our perspective in the field of knowledge. It serves also to make more clear the meaning of development of human interests through time. In a day of natural and proper specialization such an organization serves as stabilizer and a means for helping to make more clear the relation between man and his environment, and the place of the individual in the scheme of human organization.

And so, the "Sister Societies" have found represented here their many interests, from laws of atom and molecule to principles of life and religion, each fitting itself into a scheme interpreted in terms of human interest and conduct. The two hundred years of history behind us have seemed perhaps to make more wide the gaps between our various departments in the scheme of knowledge. Before us lies an opportunity for service in picturing through synthesis of these divergent elements, a universe of nature and of human life more wonderful than that which we have known and destined to give us ever-increasing joy of living.

MAKING A LIVING—OR LIVING

Out of the years in academic service, I think often of a mining senior who applied for advice as to work of special value for his last semester. One subject recommended was in petrography, a study of rocks important for creative work in the profession. With reference to the theoretical nature of this course, his comment to me was: "You don't seem to understand that I plan to make a living when I graduate." I said: "Is that all you intend to do, and are you expecting to do it all in the next year?"

Of several positions available after Commencement, this man secured the one with highest immediate salary, and probably with smallest ultimate prospects. Although this incident occurred more than twenty-five years ago, the story ends just there, as I have not heard of him again. But I trust that he is making a living.

I sometimes wish there had been presented to the senior a query that seems often to bring out the true aims of living. It is expressed in the remark of a man who was asked: "How may one's real interests in life be determined most easily?" He replied "By asking yourself what you would do if you had a million dollars and no obligations."

Perhaps possession of a sum appearing very large to most persons might warp vision and produce unnatural ideals. But in the opinion of the one who suggested this question, removal of obligations uncovers the soul to such an extent that its real desires and interests are laid bare. Until these factors are determined, life may be guided by objectives not coinciding with true personal interests, or may be lived without purpose, and therefore without special enjoyment.

There are no greater questions than those which concern our own real desires as to the kind of life we wish to live, the type of progress

Address at the ninety-eighth commencement of New York University, June 11, 1930. 11 pp. New York: New York University, 1930.

we hope to make, and the extent to which we may have joy or sport in doing. Others may inform us as to opportunities. Only the individual himself can decide what his personal interests and pleasures are. One of the appalling things of the world appears in the multitude of cases in which the field of work is almost completely separated from that having to do with what are considered the pleasures of life.

In boyhood I had an acquaintance who really liked to plow. His furrows were always straight and clean. The crops on his land were always good. The young man walked into a town some miles distant several times each week for schooling. He had joy in the work. In other words, he also lived.

In a region remote from civilization in the West I saw the opposite. It was a man who worked fiercely for 345 days in the year in order to accumulate about $400. He saved this sum for the specific purpose of spending it all on one wild debauch within a period of approximately ten days. He explained to me that his philosophy of life was different from that of other men. In a sense he made a living, but his field of enjoyment was totally different from that of his work. My last information regarding the situation indicated that he was holding a lower position, and had neither ability for hard work nor interest in the concentrated sort of enjoyment to which he had become accustomed.

As important as I believe the difference to be between just "making a living" and truly "living," it might be difficult to construct a fully acceptable definition for either situation. To some, "making a living" represents only what is known as "keeping soul and body together." Others think the situation depends upon whether you are employer or employed.

In many cases "making a living" means only the pyramiding of elements originally necessary for maintenance of life. As the scale of living changes, requirements extend the need for accumulation of money, of power, of influence, and of all the things which have relation to sustaining of life and social position. The man who spends $100,000 per year merely in keeping up his home feels that disaster is impending if reduced income makes possible application of only $90,000.—So the making of a living may involve $5 per day under certain conditions, or $500, or $5,000 under others. At any rate, we may delude ourselves into thinking that mere con-

tinued widening of the range of accumulation is a part of the need for support of life.

In a large percentage of cases significance of the life maintained has little relation to the factors involved in making the living, or in continuing the conditions which it establishes.

In the same way it will be found that what constitutes true "living," or use of the life concerned, is everywhere a subject of scientific and philosophic discussion. Especially is an answer important to those for whom education has presented a relatively broad picture of the possibilities.

In the larger world of things alive, "living" keeps pace generally with physical growth. Even for those relatively rare groups that attain a so-called stage of maturity, this condition continues principally for the period of reproduction, the end of which coincides with termination of life.

In humans, as contrasted with other creatures, development of what we call the "intellectual" and "spiritual" brings a new kind of living and of growth. It is something more than mere continuing physical existence. This is not to be considered as occasional or incidental, but is a basic and outstanding character of all human beings.

The extent to which stages in intellectual and spiritual development in man may correspond to those in physical development and maturity, or may perhaps extend beyond them, is one of the interesting problems of "living."

Among other creatures, as for example, in families of wild horses and cattle, the young remain within the home circle, and have a relatively pleasant life, until they have learned the tricks of feeding, running, and fighting off the lions and hyenas. In human families, with the added intellectual features, there are more kinds of things to learn, and education for life extends farther.

The school substitutes in a measure for the family. The accumulated thought of mankind is spread out for our examination. It calls attention to a few of the various windows that may be opened towards the farther regions of space, and time, and human experience. Through the glass of the telescopic window we draw near to distant worlds. Through the eye-piece of the microscope we visualize the amoebas and microbes that plague our bodies. Beyond the glass of history pass processions of the ages. The

school also helps to develop imagination, and suggests how dreams may build themselves into realities.

At the end of even the relatively long period of human training we, like other creatures, enter the business of keeping wolves or hyenas away during the process of "making a living." Our physical growth is already attained. Preparation is also made for intellectual and spiritual life. The responsibility of "making a living" is seen as a duty. A portion of that which relates to intellectual and spiritual living may begin to look less urgent. At any rate, it sometimes appears to us as if the poets, with much of biography and history, and theories of economics could be laid aside. So, after all, the major effort for intellectual and spiritual development may practically end near to the time of attaining full physical and mental capacity.

In considering what constitutes "living" it is important to note that for some the joy of mere activity may be an adequate reason for existence. Also one must give full value to the things which have been called purely physical pleasures. Each has its honest and important place. But the fullness of feeding, the joys of taste, the stimulus of drink, and the smell of violets will soon have been experienced. All the way through to sex, each has its function, and each may be debased to some form of intemperance.

Then, building up, from what may also be basically physical things, in the course of living, we pass by way of other senses through sound to what in music is possibly of all human arts the most highly developed. Through sight we find form, color, and perspective bringing us to a stage where we have long struggled to realize the fullest possibilities of art. In our development of these more subtle and complicated aspects of appreciation, we learn also that of all enjoyments, those that have the deepest and most nearly permanent influence arise through response of emotions to stimulation of what we class commonly as intellectual materials.

Unfortunately in everyday making of a living, multitudes there are in whom there seems little response to things of beauty, or of mind, or spirit. They never see the gold in green of spring, the tingling silentness of night has not appealed to them. Nature expresses itself mainly through physical pleasure, or as fear. They can no longer read a solid book,—but still try to obtain life through

those senses that concern more particularly the physical being. No wonder personality often fades before the age of fifty.

It seems only a few generations back to a time when, with ending of the cycle of purely physical living, old age asserted itself near forty-five. The interest and enjoyment of living largely vanished, and only rare individuals carried on. Whether or no the span of human years has been lengthened, we have now at least the protective mantle of preventive medicine, and the guardianship of temperate living. I believe that with these factors comes also a regenerating influence of enormous importance in our better understanding of the purposes of life, better relation to our fellow men, and fuller enjoyment of those eternally developing aspects of living which have to do with intellect and spirit.

Today old age may come with hardening of arteries, or with loss of enjoyment in living. It may be at ninety, it may be at graduation. One of the critical elements depends upon the objectives of the life, and the plane upon which it is conducted.

I sometimes think that, knowing we have a life, we must either decide what to do with it, or accept what it does with us. Some believe that living is, anyway, largely a matter of fate, depending on the breaks of the game. But in most games the sport consists in doing the best with available talent, and especially in making use of the breaks.

As illustrating the great social significance of continuing development in intellectual life, I may only mention the fact that a government of the type with which we are now experimenting can succeed only if those who vote are sufficiently informed as to facts, and trained in judgment, to permit their serving as the ultimate source of authority. Democracy cannot exist if the people fail to maintain continuous education at a level on which they can give clear-minded consideration to great questions. Assumption of franchise means continuous study of a stream of new problems. This duty alone involves initiation of a process of education which must continue through life.

Another phase of modern activity to which attention is turning with increasing pressure relates to the idea that, solely with reference to the joys of day-to-day living, education should carry on with intensifying interest through the years.

This movement for continuing education of the adult not only

concerns the roots of democracy; it is also the most potent influence for maintenance of youth. Had Ponce de Leon been able to read the future, instead of attempting merely to add one more to the number of springs and fountains with reputation for stimulating or curative effect, he might have contributed towards the movement to stimulate intellectual and spiritual growth through life.

And so I believe that now, as at no other time in history, we see the difference between merely completing the cycle of an individual human life through "making a living," as contrasted with the opportunities for service and enjoyment through planning "living" of the life with reference to ultimate accomplishment and the joy of doing. Not at any other time has this seemed so clearly essential for the individual, and for the race.

Four outstanding results will come from building into the period of "making a living" a continually expanding structure concerning particularly the intellectual and spiritual life.

It will, *first*, contribute to better understanding of the situation of each individual, so that with wider vision we may select the things for which we have greatest capacity, and through which we can have largest accomplishment.

It is, *second*, by this means that we allow ourselves the maximum opportunity for carrying a responsibility to our fellow men through assuming the true responsibilities of citizenship.

It will, in the *third* place, increase opportunity for continuing enjoyment of those things which represent the flowering of human effort in arts and sciences, philosophy and religion.

And, *fourth*, it opens an ever-broadening realm of interest in living, which may conceivably double the effective life in years, as well as in the measure of joy for every portion of it.

My own special researches have been devoted in some measure to uncovering the more remote past. The objects of this work concern the significance of what happened there—and more particularly with reference to its meaning in terms of the human present and future.—In the same spirit in which approach is made to these problems, involving the importance of a "past that lives," I present myself today to plead the cause of "true living" in the present on the part of the human individual, and for the whole span of his years.

I am holding no brief for any doctrine, creed, or theory. My

interest centers, first, upon knowing the truth regarding what has been and is. It rests secondly upon desire to see the principle of intellectual and spiritual growth embedded in individual lives.—Before the soul may be considered as candidate for immortality, it must first be tested by responsibility for use of the life that is given.—From whom shall we expect re-creation of what we may allow to die?

THE SEARCH FOR SPIRITUAL LEADERSHIP

SPIRITUAL, as I see it, represents the highest elements in human life. Strictly interpreted, all human leadership must be spiritual. However we may define high intellectual attainment, when you consider a relationship as something consciously influencing other persons it must arise from the essence of human living.

One aspect of this problem that troubles us concerns distinction between the qualities known as emotional and those called intellectual. Seen from one position, everything that touches the spirit and concerns leadership ultimately transmutes itself into emotion. The great scientist developing his project to the advantage of mankind is moved by strong personal feeling. Dr. Michelson, who passed out of this life a few days ago, confessed that his enthusiasm was emotional, and that he was guided in large measure by what one defines commonly as art rather than as cold-blooded science.

A few months ago I spent an evening with Dr. Michelson in order to discuss his project for measuring the speed of light. He talked little about velocity of light and much about art and the emotional enthusiasms which lie behind the applications of art to science. Around his room were several dozen water color sketches, his own work. All had been done in leisure hours between periods of scientific research.

Referring to his personal methods of work, Dr. Michelson said, "My science is a development of the art of doing a particular thing extremely well." Had you watched Michelson at work, it would have been clear that he was each time attempting to put a little more art into use of the mirror with which he was measuring the speed of light. It was his lot to be a scientist, otherwise he would have been a great artist. The scientific worker who deludes himself into feeling that he is free from emotion may not have the enthusiasm urging to great attainment.

Address before the Washington convention of the International Association of Torch Clubs, Inc., May 1931. *Torch Magazine* (Buffalo), vol. 5, no. 1, pp. 3–6, January 1932.

In questions concerning leadership as it relates to the spiritual, I am inclined to think that the emotional has as wide a range as in any capacity in which it serves mankind. When I speak of feeling in this sense, I am not thinking of being swayed by the music of a voice or by the appealing force of mere words. I have in mind rather the influence of an individual stimulating others to high levels of thought, or a situation in which the true value of an idea may extend to those whom it touches.

In the history of great movements you will find that they are commonly stimulated or developed under conditions representing emotion of a high type. It may be a great joy; it may be great sorrow. A personality steeped in sorrow often sees life through a glass which makes the unessentials drop away. As evil as war may be, the conditions arising from it make soil from which grow many of the finest human relations and some of our greatest ideals.

Discussion of leadership in the specific field of *art* has brought into consideration the differences between art and science. The artist concerned with painting, poetry, sculpture, feels that what he does has an emotional message wholly different from the things which the scientist has in mind. Yet I am convinced that when the experience of the scientist reaches its highest level of reality in the sense of human appreciation, the scientist and artist are standing on approximately the same plane. Art has one way of presenting its message, and geology has another. The scientist might tell just as great a story in giving you an account of the movement he finds in past history of the earth, as would be done by a great poem on the landscape as it presents itself to spiritual vision.

In spite of the fact that it is often set aside as unpractical, and not belonging to the everyday things of life, art is one form of expression of the emotional nature of man which is certain to have its place in every phase of human activity.

That element of the harmonious underlying art is one of the greater things of day to day life. There are some who exist without deriving much from living. Many go through life seeing little that is wonderful, and probably less that is beautiful.—I sometimes awaken with a start in realization that there is a great and wonderful world around us; and that we may go about in it blind to beauty and unaware of joy. If these ideals could have expression in our lives,

no matter what the daily work or where we are at home, life would be distinctly more worth while. So, leadership which expresses itself in art may be one of the greatest of all contributions to human life, whether it be through painting, or literature, or science, or something carried out in an exceptional way in business or in government.

If one considers spiritual leadership in *education*, it is interesting to see what would happen if this activity were developed to the point at which it could rest upon inspiration. What a different world it would be. Routine turning over of knowledge has little significance. Almost the only thing that counts generally is spiritual inspiration stimulating the student to a development in which there is recognition of fundamental human values in everything with which we come in contact. This morning I looked up the collected speeches of a great teacher, Benjamin Ide Wheeler, to see if I could find the conclusion of a brief address at the dedication of a new building. In this statement Wheeler referred to the university as a place where, under the mysterious influence of inspiration, vision shall awaken vision, and personality shall give its spiritual life blood for handing on the torch of life. Perhaps this is something to write on the coat of arms of the Torch Club.

I look upon spiritual leadership in education as one of the great opportunities. It is largely neglected. In the future it may produce a much more extensive and much more fundamental power than education has seen. With our modern highly organized program we have passed a long way from the early stages of education, in which teaching was reduced to a minimum, but thinking and the practical applications were developed to the maximum.

In considering spiritual leadership in *science*, perhaps I begin as prejudiced. But this has not always been true. My first contact with science was when I came home from grammar school to report to my mother that the teacher had talked to us for fifteen minutes about the idea that the days of creation described in Genesis were long periods of creation and not days of twenty-four hours. My mother and I held a consultation—she being a Scotch Presbyterian—and agreed that this was rank heresy. But a seed had been sown. I have been backing away from that position through subsequent

decades. I realize now that the elements of science, so far as creation is concerned, represent the uncontaminated and unmodified record of what the Creator did.

The longer we live in contact with science the nearer we come to realization that little is known concerning what is behind nature. I am quite clear that whatever this is it is a much greater, a more wonderful, a much more powerful, a much more beautiful, and if you wish to state it in that language, an element with more human appeal than has commonly been represented in the great documents on this subject.

Some time ago a friend said to me: "Your theory of evolution is good, excepting that you have no place for a beneficent Creator." The reply was that if what has been created leads us to a situation in which we can develop an idea of the origin of the world, and its development, and its possibilities; and if, moreover, the conditions are such that we can find this out for ourselves instead of being told, then we have the maximum opportunity for satisfaction through growth in knowledge and its use for our own betterment. As nearly as we can determine, we are in a universe where the laws of nature, and the intelligence given us, permit growth and development through our own efforts.

And this view of the world brings me to restatement of the idea that when students of religion, art, education, and science come together they find that they are dealing with intimately related aspects of knowledge.

Leadership in *religion* I have already touched in some measure. From my point of view, religion is an attempt to crystallize in one group the influences which seem essential in life. Philosophy differs from science in that it will go as far as logic can take it. Sometimes it rises far from the ground. The scientist must carry his facts with him, and must be sure that his theory checks with the facts. But human kind wishes to have answers for such questions as: what is the ultimate source of all things; and where are we going? Some insist on having an answer regarding whence and whither. Religion, as one of its functions, attempts to furnish something in reply to these inquiries. Science is conservative and only goes a short distance. Philosophy reaches a little farther. But religion, by the very nature of the case it states, must reach out

toward the limits in order to find a foundation upon which those who are not philosophers may stand.

Religion is not all of this phase. It is also a manner of life, or an attitude toward life, based upon such knowledge as can be obtained concerning ways in which individuals may best adjust themselves to each other. Due to the nature of the situation, religion must crystallize its statements in order that they be used readily. From time to time, through the ages, it has been necessary to dissolve and recrystallize these ideas. There may be times when science and philosophy step ahead of religion so far as definition of the fundamentals is concerned, and then religion restates its case. Like science and philosophy, religion develops or grows in adjusting itself to the stages through which humanity passes.

As to whether there can be spiritual leadership in *business*, I say "yes." Many of our greatest business men are really spiritual leaders. In much of business the principles of acquisition and accumulation reach a stage at which what we call competition may not be on a high ethical plane, but there are few situations in which the individual has greater influence upon those about him than through operation of business.

Someone remarked recently that: "There was a time when the political power of the Roman Empire was the dominating influence in the world. That was succeeded by a stage in which the Church took over power from the Empire and became the dominating influence. Today the dominating power is big business." It is clear that a definite spiritual influence is exerted in the United States by business enterprises. I believe that in a large percentage of cases this power tends to do good, though there are many in which you find it lagging or destructive.

Washington is a dangerous place in which to discuss leadership in *politics*. But it is one in which you are concerned primarily with human relations, and in which the highest ideals must be followed.

In this country we are helping to carry out a great experiment in government by the people. With our particular kind of organization the political party is for the moment considered essential. In a dictatorship or a monarchy this type of organization is not necessary.

Sometimes the party arises because a great principle or a great

leader influences us. In a large percentage of cases it is held together by what is known as political expediency. One group does something for another, providing it may have support in meeting its special needs. We may start with the assumption that the results justify the means, and that the arrangement gives solidarity necessary for continuation of party government and upholding of stable administration. But there should be no doubt that some of the greatest dangers to democracy arise out of possibility that the things involved in exchange may not contribute to the interest of the country as a whole. If not of national significance, they can become a grave menace.

Spiritual leadership, in the sense of holding to the things that are high and of good repute, spiritual leadership representing the truth and nothing else, is essential in development of our type of government. If we do not have it the end is near. You may then take your choice between dictatorships or monarchies on one hand and other ways of governing yet to be tested out. Do not forget that through the ages there has been experiment with many varieties of human organization. Democracy is new and yet old.

I have touched very lightly on several aspects of leadership, in which the spiritual relation seems important, perhaps doing nothing more than to present my personal point of view. Instead of framing a summary of ideas or of opinions I might express all that is suggested in concise form through the words of Paul's message to the Philippians:

"Finally, brethren, whatsoever things are true, whatsoever things are honest, whatsoever things are just, whatsoever things are pure, whatsoever things are lovely, whatsoever things are of good report; if there be any virtue, and if there be any praise, think on these things."

I am not sure that there has yet been made a better statement as to what furnishes the elements necessary for spiritual leadership.

REMARKS AT SCIENCE SERVICE ROUND-TABLE CONFERENCE

These few minutes I wish to devote to what might be called the art of stating scientific truth. This is in considerable measure the function of Science Service. The limit has not yet been reached in development of scientific literature. I recognize literature as perhaps the greatest of all arts, the most human and also the most picturesque.

Nearly everything that comes within the range of science has existed for a long time. I am not sure that mere discovery makes anything more important than other things. I have known cases in which reporters mistakenly brought out old things as if entirely new, and with great success. It depends upon the form of statement and the human interest.

I wish to suggest, but not for Science Service alone, that there is a zone of difficulty and of danger precisely at the point where the press would like to secure new material. I presided yesterday in a meeting where four men presented extremely important statements on the results of scientific research. Among these papers there was considerable difference of opinion. That was the reason for the conference. It was because men see problems from different points of view. When the investigator begins his task he is trying to advance a fraction of an inch further than any one else has gone. A stage is passed through in nearly every investigation where the result is not clear and therefore can not be stated clearly and simply. If this were possible, it would not be necessary for the investigator to concentrate on this problem.

The fact that the press desires to have new material is extremely important in development of scientific research because it stimulates the investigator to attempt a clear statement of the thing he is trying to do. Not infrequently the fact that the public desires to know what the man is attempting acts as a stimulus to the investigator and helps to clarify his thought. It helps the researcher

Remarks at the Science Service Round-Table Conference, April 27, 1932. *Science*, n. s., vol. 76, no. 1964, p. 155, August 19, 1932.

himself to secure a clearer idea of what is attempted. Beyond this there is a further stage at which the problem is seen clearly. It is then necessary to formulate it in terms which represent application of the art of stating scientific truth.

The best form in literature is based first upon accurate statement, second upon logic and third upon artistic presentation. If a fact is to be stated clearly, it must stand in striking contrast to its background and yet be related to that background. It is essential also that the element of human interest be included in the picture.

There is an art in use of thought and language in presentation of scientific truths. This art may well challenge the interest of any scientific man. There is always opportunity for improvement. I congratulate Science Service on its success to date.

THE NATIONAL ACADEMY OF SCIENCES—DEDICATION OF BUILDING

Mr. President, members of the academy and research council, and friends, in the midst of distractions incident to the great national struggle in progress in 1863, the Thirty-seventh Congress of the United States gave evidence of vision in many exceptional ways. It opened the great West to settlement by homestead, and authorized construction of a railway to connect the Atlantic with the Pacific. It was through unanimous approval of this Congress and the approval of President Lincoln that the National Academy of Sciences received its charter. Though the founding of the academy was in a measure planned with the idea of strengthening the national defense, it was clearly the purpose to reach beyond necessities of the moment and to consider the importance of advancing knowledge and its application for future benefit to the Nation.

When the incorporators of the academy were called together, Senator Wilson, of Massachusetts, in transmitting the commission from the Government stated that while some had thought the time not well chosen for such action by Congress, he wished to have the world realize that "the statesmen and the people of the United States in calm confidence . . . are fostering the elevating, and purifying and consolidating institutions of religion, benevolence, literature, art, and science."

It soon became clear that if the academy were to serve the Government fully in the rôle planned, there must be opportunity for better organization and better contacts, first among its members, then with other organizations, with the public directly, with the agencies of our own Government, and with scientific bodies of other countries. It was evident that this must come through developing machinery which could be set up only if permanent quarters were available in the Capital City and in close relation to the agencies of the Federal Government.

Address at the dedication of the building for the National Academy of Sciences and the National Research Council, Washington, April 28, 1924. *Science*, n. s., vol. 59, no. 1532, pp. 407–408, May 9, 1924; *Annual Report of the National Academy of Sciences, Fiscal Year 1923–24*, pp. 46–49, 1925.

The ceremonies in which we participate to-day bring to us, in what seems like sudden fruition, the results of the vision, the plans, and the hopes of many years. Knowing as we do that the joy in recognizing advance is itself essential to progress, this would seem the natural time to halt for a moment of pure pleasure in contemplating the attainment. But more important to us than mere appreciation of accomplishment is the realization that this is also a time at which we should consider with utmost care what these newly established conditions mean in terms of further opportunity. We must not fail to realize that these pleasures of possession have intimate relation to responsibility for that which we have helped create, as also for the new and great possibilities of service now opened.

So while this is first a day of rejoicing that possessions have been secured and ideals have been realized, it is most of all a time for earnest consideration of the great things this advance may mean for the academy and for the people of to-morrow.

In viewing the future responsibilities of the academy to the Government we may not interpret this relation to mean merely the possibility of assistance in specific problems or researches as they may happen to arise either in relation to national defense or in other connections. There can be no doubt that this body was chartered with the understanding that it would have always in mind the interests of the people in whatever ways science can contribute to meet their needs or support their ideals. Though it is clear that the academy represents expert knowledge in the sciences only, it is important that its vision of ultimate service reach over all phases of the Nation's life and thought, ranging from defense to assistance in securing those guaranties of comfort and health in body and spirit which make good citizenship and happiness possible.

Now, for the first time, we are to have a home, with all this means as a place to live and work. It seems clear that as one of its responsibilities the academy with its relatively small membership, comprising all of the sciences, should look forward to its general and special meetings here as exceptional opportunities for bringing the whole range of scientific inquiry to bear upon new discoveries or upon great investigations in progress. Even more important than the general meetings will be the possibilities of those frequent intimate conferences of small groups brought together for discussion of

special topics, in which, with a minimum of formality, the more fundamental discussion is made possible.

The bringing of the National Research Council into being on the foundation of the academy charter has extended greatly the possibilities for stimulation and organization of research. In occupying its quarters in the new building, the academy will come into a relation to the council which will bring out more clearly than at any earlier time the significance of the organization which it has brought into existence. The invitation to a large group of the national scientific societies of this country to participate in the work done through the research council has developed a wide range of relationships of the greatest importance. The responsibilities and opportunities which present themselves to the academy in connection with future problems of the research council must be reckoned as among the most important which will now come closely to our vision.

In the future development of foreign relations in scientific work there appears also one of the very great opportunities for national service. There is good reason for believing that the possibility of some of the surest ties to be formed between the nations lies in the discussion of scientific and intellectual questions, in which international cooperation is directed specifically toward search for the truth without reference to its immediate economic or political bearing.

Along with those relationships of the academy which have been considered there is also open to this body, as to other scientific agencies, an exceptional opportunity and responsibility for aiding to steady the thought of the people by interpreting in some measure the meaning of the rapid advances now being made in scientific understanding of man and his environment. With the continuing growth of knowledge we see the universe increase in complexity and extend itself vastly in space and time. It is to be expected that adjustments in our scientific data will bring into continuous review much that pertains also to the fundamental philosophic and religious thought forming so important a part of the world's thinking. We should never blind ourselves to the fact that the people have philosophies now, and always will have them, and that consciously or subconsciously they have religious beliefs, also. Abundant national disasters, some of which we have seen in recent decades, have

demonstrated fully that there is nothing more deadly than bad national philosophy, especially if it translate itself into terms of economic or political policy. Such beliefs never arise from attainment of the truth, but always from the lack of it.

The academy will always be conservative in holding fast such knowledge as may seem securely founded, but it will never look with favor on the defense of any view merely because it has been held. The attitude of the academy as representing truth-seeking and truth-accepting should have a continuing influence in stabilizing thought. Though we may never be advocates of philosophic or religious systems, we should assist in that interpretation of the shifting panorama which the world seems to present when viewed through the eyes of science. And we should help to keep false assumptions from serving in the place of truth.

SPIRITUAL VALUES AND THE CONSTRUCTIVE LIFE

THE subject of this meeting differs from those of preceding sessions, in that it relates to comparative values in life without reference to particular fields of activity.

As the spiritual concerns both man as a being and his purposes or ideals, the discussion could properly turn itself in any one of many directions. It might look towards examination of the spirit or soul as an aspect of being, or into consideration of future spiritual life involving problems of immortality. From the point of view of this paper the spiritual in man is seen in terms of the manner of his life, and of the materials which are, so to speak, his food and drink. His ideals are illustrated by the types of opportunity which he selects.

Influence of the university in formulation of thought relating to spiritual values will depend in part upon attitudes taken in the many special divisions of knowledge represented. Three great fields have been covered already in the sessions on education, economics, and government. In all of these, spiritual values have been considered. In this particular session Professor Hocking will speak from the point of view of philosophy; Mr. Noyes will touch on ideals in literature and their relation to certain aspects of religious thought. Along with other points considered in this particular paper, examination is made of the view represented by science. Comment is also made on the importance of art with particular reference to its expression in nature, as an influence upon spiritual values and ideals. This Conference was intended, as I understand it, to give a forward look; not that we see the next one hundred years, but that we concern ourselves with attitudes towards what will be taking place in the coming decades.

I should say that all of the papers in this session have been written with reference to this forward look. We are, however, considering a very difficult subject, in which it is desirable to discuss more

Address at a conference of universities under the auspices of New York University, New York, November 15–17, 1932. *The Obligation of Universities to the Social Order*, edited by Henry Pratt Fairchild, pp. 317–331. New York: New York University Press, March 1933.

particularly the attitude of mind concerned than to attempt prophecy relative to what may take place within the next one hundred years.

First, regarding definitions: Though attempt to define such intangible elements as spiritual values cannot result in a perfectly clear picture, it may be desirable to indicate certain points of view as guiding in this particular statement. It is realized that if effort is made to describe even an attitude of mind representing values of the spirit, we encounter difficulties of the order met by the biologist when he undertakes to define the unfathomed phenomena of life, or of the physicist in endeavoring to say precisely what a light impulse or an electron is. And yet we feel as certain regarding the existence of these elusive spiritual elements as of life, or of the realities called material substance.

Not only do spiritual qualities place clear imprint upon the human, as contrasted with other less exalted beings, but among categories of mankind they distinguish the living clay image type of creature from that which radiates constructive interest and strives for touch with the eternal.

Wisdom of all time falls short of exact delineation or evaluation of spiritual elements specifically, and the situation becomes increasingly a problem when such characters are considered in a broadly comprehensive sense. The spiritual may arise through functioning of that which makes possible the farthest vision in space, time, aspirations, and ideals of man seen as a being aware of himself and of what is around him. It expresses itself, in part, as capacity for determination of relative values. And again it represents the conscious understanding of what is clearly the greatest good in the longer time.

Recognition of ability to appreciate comparison of values in life carries implication that an appraisal of the individual himself is given by his personal attitude towards this situation.

The nature of our opportunity for adventuring in this wider universe of the spiritual has been stated in many ways. An often repeated formulation—"As he thinketh in his heart, so is he"—does not define merely an emotional attitude. It describes an outlook on desires or aspirations in the individual. This conception regarding points of view, or of ideals which are fundamental, is the basis upon which the spiritual is constructed. However these qualities

or values are finally described, they are at least reflected in our attitude of mind towards ultimate views as to what in life is most significant.

I was pleased in Mr. Lamont's discussion to have him turn aside and make reference to a comment of Mr. Dwight Morrow, our late distinguished citizen, with reference to relation between points of view. It reminded me of a statement by Mr. Morrow some years ago in which he said, in referring to international relations, "I always prefer to look upon a people in terms of what it desires to be rather than what it is or has been."

Seen from one angle, the spiritual element may appear to represent the farthest removal from so-called practical living. For purposes of this discussion it is necessary to recognize the interpenetration or intertwining of all elements in life and among them the place of the spiritual as one form of its expression.

In considering relation of the university to a future social order, it is difficult to avoid asking how far altering of conditions might influence spiritual values. Will shift in ideas mean also evolution of ideals? Or shall we look upon possible changes as leading only to varying degrees of appreciation?

Among the truly great vistas opened in recent years, the past revealed by the historical sciences has made us so clearly aware of an almost infinitely extended process of development that the mind finds it difficult to avoid acceptance of a future involving comparable changes. Such a view has its immediate effect upon attitude towards life and its consequences, through suggestion of continuing growth. Will such influences exert themselves in the field which we describe broadly as the spiritual?

Over the ages our attitude towards conduct and morals, as such, seems to shift. In the future, as within this particular period, an act considered good form in one generation may be occasion for a fine or jail sentence in the next. The critical question concerns relation of such differences of opinion to change in spiritual concepts. The increasing tendency to frown upon selling a man something he does not need, and does not want, is not only good business and good morals, but it is founded on principles that make for eternal benefit.

Suggestions regarding development in a so-called basic "golden rule" are in accord with the idea of advancing coöperation as con-

trasted with unfriendly competition—"Do others before they do you," which is said to have been replaced by "Do unto others as ye would that they should do to you" and later by "do for others," represents modification in the direction both of scientific evolution and of appreciation for spiritual values.

Unless the future differs radically from the past, we may be sure that the social order will itself be altered by advance of knowledge. A stream of information that we do not now possess will sharpen vision to such an extent that social organization, government, and economic relations will move towards new adjustments. Under these changing conditions, it is to be expected that knowledge will help to clarify spiritual values.

Growth and development are essential in life. Plans for the future that leave such possibilities out of consideration will be inadequate. The extent to which appreciation of the spiritual will increase may be problematical but, whatever the situation, the opportunities must be widened.

As to the function of the university in relation to spiritual life: The responsibility of that institution with reference to interpretation of spiritual concepts, or ideals, is seen as its greatest problem. The duty includes furnishing clear truth regarding the world of realities in our environment of things and of people and, most of all, aiding to develop understanding and appreciation of ourselves. The university is not concerned with proselyting in the interest of beliefs, but in giving a safe and sympathetic interpretation of the human situation as it really is. In addition to consideration of realities, their analysis and synthesis by scientific and other methods, the university must present the world of ideals, comprising the highest attainments of human faculties. Among other subjects within this realm will be art with its companion beauty, philosophy with its statement of what seems logically best, and religion expressing the basic convictions of mankind.

The outstanding aim of the university is clearly the giving to life its widest vision on the highest plane, and in presenting objectives which offer the largest opportunity for satisfaction over the longest time. There is a further duty so to picture the possibilities before each individual as to make evident the value of the constructive-growing-building type of life as contrasted with that which represents only the routine of generations and occupations.

From a conception of university function leaning towards humanities and philosophy, modern institutions have turned in some measure towards scientific analysis and teaching vocations. It must be recognized that much of the effort given to development of careers in medicine, engineering, teaching, etc., has concerned the really higher purposes of these activities along with organization of information. Whatever faults are to be found in the university system may not lie in mere tendency to fact gathering, nor to interest in vocations. Such difficulties as exist are more largely due to absence of that which is fundamental and necessary for real success in a vocation. It is not so important to consider what a university has and does not need, as to know what it needs and does not have. There may have been too much effort put into training to make a living rather than teaching how to obtain the most out of life. Somewhere there must be a place at which the higher values are the subject of investigation and of interpretation on the basis of available knowledge.

If one accepts the idea that the university teaches how to live as regards maintenance, effectiveness, and enjoyment, it is important to reach a decision as to what may be looked upon as real values, and this is the subject of Professor Hocking's discussion. In recent years our mode of thought has been influenced largely by consideration of what, under the trial of time, constitutes "practical success" as compared with that which is idealistic. "Getting things done" has also been seen as important, often without consideration of real need, or of the means used. It is to be hoped that we are near the day when all action will be judged in terms of means as well as of the end, before the results are accepted. History is made up too largely of sequences of mistakes as to means used to attain desired ends.

It is important that the university regard as a primary function honest and sensible comparison of the immediately practical with the ultimate ideal. Excepting by accident, no great work was ever accomplished by one not imbued with ideals. Over the ages idealists, filled with enthusiasm for great truths, have been the leaders and creators. Real strides in human affairs have been due in large measure to their efforts. While machinery of business or of government may be kept in motion by activities that concern things of the moment only, the world waits until men with vision

come to perform what has been called the impossible, or to make real the things which have been considered impracticable. It is a part of the function of the university to make unavoidable an understanding of reality and truth, as applied to all matters touching life, and to indicate that for these there may be no substitutes.

Influence of the university upon development of spiritual values will be in part through effect of its broader views concerning attitude of mind. Partly, it will be by guidance in statement of ideals expressed in special phases of knowledge. As illustrating this aspect of the problem, consideration is given in this paper to influence of science, the particular field with which the writer has closest touch, and to art as involving especially our relation to nature.

Points of view developed in examination of other divisions of knowledge will be discussed by other speakers not only in this session but in those which follow.

Situated as we are in the midst of an infinitely complex mechanism of natural elements practically controlling our lives, it would be remarkable if the continuing imprint of nature upon us were not among the dominant features of life. In the present epoch of discovery contributions are so voluminous, and so fundamental, that we may not avoid considering how our attitude towards life and its ideals is affected.

The material world, as once recognized, has vanished, and in its place appear energy complexes intertwined in their relationships to exhibit a new universe. Extension of our view into unbelievably remote reaches of space, time, movement, and power has not diminished evidence of universality in expression of what are known as natural laws. In general it has tended to increase belief in unity of relation and operation in what we find.

It is but a few years since Huxley and others called attention to the fact that man had a place in nature, and that human beings, like life as a whole, have relation to an environment of which they are in one sense a part. Within the last two generations we have come actually to see man as emerging from the wilderness of his past with all its untamed inhabitants. And we are just in this day obtaining a clear picture of humankind making for itself the beginnings of civilization.

Human life is now seen as fitting into a broad movement in a universe of enormously heightened interest and importance. With

this change there is unavoidable recognition of an enlarged meaning and added dignity in life by reason of the relationship. Man no longer lives in an isolated present. We recognize the past as not just a static ruin without significance to us. We see the future not merely through vistas between castles in the air, but as representing something coming to be, the character of which may be bettered or marred by that which passes through past and present to future. The stream of this movement is in part through us, and therefore partly under our influence. The place of man in this scheme of development is given enhanced importance by our growing belief in the order of the universe and its meaning, and in a possible small place which we may have in it.

In the light of modern knowledge the wonder, and power, and beauty of the natural world are not less. Some have looked upon beginning science as dissecting nature into its ultimate fragments, in which the elements of inspiration seemed no longer to have place. But modern synthesis of these materials sees the parts returning each to its normal position in a world more wonderful and more beautiful than it could be without this intimacy of understanding.

With all the boasted progress of our mechanistic civilization and its production of so-called leisure time, there is no contribution of modern knowledge that exceeds in significance the opportunity for spiritual growth made possible by science in emancipating us from superstition. This has been done in part by establishment of confidence in law, and in orderly procedure of nature; in part by understanding what the natural world represents; and by appreciation of real values contributed to the higher life.

It is a responsibility of the university to make certain that science, as a method with its results, is brought into its true relation to other phases of knowledge. This must be accomplished in such manner that we obtain full value of the enlarged view and the deeper perspective made possible by the combination. It is important that in such discussion scientists and philosophers do not become dogmatic. Desirable as it is to consider the fundamental relation of science to philosophy and religion, it is the truth, and not merely reconciliation, that we seek. The high price of beliefs and adjustments not well founded has been a heavy burden in science, as in other subjects. It is important to bear in mind also that we shall

not soon reach the limits of knowledge, nor have a complete understanding of all factors in the situation.

No matter what attitude we take towards definition of art or of beauty, there is universal agreement as to the tremendous influence of these elements upon development of the spiritual life. Whether beauty be truth, or goodness, or merely fitness, it represents an aspect of harmonious expression finding response in every field of human interest.

Influence of the university in nurturing spiritual values will be increased if beauty and art are recognized as essentials in its scheme. If a time comes when we learn to know more fully how these two elements fit into other views of life and of our surroundings, it may be possible to turn their influence more directly towards clarifying the spiritual background. Efforts directed towards bringing to the world conviction regarding value in the artistic view of relationships around us, and concerning recognition of beauty wherever it appears, are among the most potent factors available in the university program.

The fact that art may be only an especially favorable form of statement, and beauty only a point of view, does not diminish their significance. Rather does it emphasize the idea that attitude and point of view are everywhere fundamental, and especially in all that concerns spiritual values.

In these days of disillusionment regarding pleasures in mechanical speeding up of civilization, many who turn to the great realities for relief have centered interest on beauty and nature as seen together. These two combined have been a source of joy standing the test of storm and age. The face of nature is everywhere before us. Its countenance is that of creation itself, with all that we attribute to it. And it has "a smile and eloquence of beauty" that may steal away the sharpness from our darker musings ere we are aware.

A student of this subject in England, Mr. George M. Trevelyan, has seen this influence as of such significance that he writes: "By the side of religion, by the side of science, by the side of poetry and art, stands Natural Beauty, not as a rival to these, but as the common inspirer and nourisher of them all, and with a secret of her own beside."

"Whatever its interpretation may be, natural beauty is the ulti-

mate spiritual appeal of the universe, of nature, or of the God of nature, to their nursling, man. It and it alone makes a common appeal to the sectaries of all our religious and scientific creeds, to the lovers of all our different schools of poetry and art, ancient and modern, and to many more beside these. It is the highest common denominator in the spiritual life of today."

If, now, we consider relation of spiritual ideals in the university to development of the individual, we find some holding that the human problem presents its most difficult questions in matters touching guidance to the largest individual opportunity. We find also that adjustment of individual interests to those of the community, in other words the good of the community as a unit, depends partly on plan of organization, but largely upon vision of the individual as to possibilities for his advancement or growth.

The situation is complicated by influence of desire for freedom of judgment or initiative, which leads naturally to striving for true individuality. This interest may be described in part as wish for recognition, or what has been termed "a place on the map," and partly it relates to hope for accomplishment. Education concerns itself with defining and developing individuality in accordance with capacity, and giving to it guidance which will offer a clear picture and will open the way to self-expression and recognition.

The developing of individuals with known capacity, initiative, and independent thought is a work of the highest order. To stimulate intellectual and spiritual progress of persons fired with enthusiasm for constructive effort is a contribution of first importance to the community. Success in such a plan for growth of constructive individuality depends upon safe guidance through ideals, without which the effort is unfruitful. If such a program could have its full influence, the difficulties of the world would diminish by at least one half within the first year. This would be true not only of individual problems, but of those, as well, which concern the greater questions of society, solution of which is influenced by personal attitudes.

In conclusion, development of the university does not depend solely upon deciding what should be thrown out of the curriculum. It will be determined by emphasis on what is shown to be of primary significance. All support should be given to the age-old idea

that universities are institutions in which elements touching the things of the spirit must have highest place.

Just as it is said that where there is no vision the people perish, one might state that where the spiritual tends to diminish in significance, growth and joy of life decline. Tennyson put into the last words of King Arthur the statement: "For what are men better than sheep or goats that nourish a blind life within the brain, if, knowing God, they lift not hands of prayer." Perhaps he had in mind a formal prayer; he may have intended to convey the idea of prayer as an attitude of mind towards things of the higher life—and so, that men who have not this point of view may class themselves with sheep and goats.

The problem of the university of the future, so far as it concerns the spiritual, will relate in part to appreciation of relative values and in part to things connected with continuing development.

The university must itself be constructive and not iconoclastic. It must recognize the individual as a being essentially of spiritual cast, that may crave individuality defining itself in terms of constructive or creative work. It should help to express in those who seek its guidance that quality suggesting the inscrutable germ of living things, begetting growth and building upward; or like a living flame, which lights the region round about, but does not cause its own destruction. Through such contribution, more than through any other, the university of the future will influence human progress.

REMARKS BY CHAIRMAN INTRODUCING ALFRED NOYES, CONFERENCE ON THE OBLIGATION OF UNIVERSITIES TO THE SOCIAL ORDER

In this program, the next speaker, Mr. Alfred Noyes, comes to us from England to participate in this discussion. I was about to introduce him as a man of letters, when it occurred to me that such a title might not be sufficiently comprehensive. I recall that my first relation to Mr. Noyes was in the study of a great work in which he considered the watchers of the skies, those who looked through the huge hundred-inch telescope into remote spaces of the heavens. When, again, I went to study the story of the Grand Canyon, I found Mr. Noyes writing a work called "The Book of the Earth." Again, when I wished to recommend to a young investigator a statement of Darwin's point of view when, as a young man, he was developing the great conception later to represent his life work, it was a publication by Mr. Noyes that I used. On reading his works more carefully I found that he recognized the shortcomings of scientific philosophy, as of a blanket covering the universe only partly, and that there was suggestion of greater things involved in the philosophy of science, and in the science of philosophy, elements which reach out to include human feeling, and which touch those deeper things which we call religion. I agreed with Mr. Noyes's idea that poetry, the vehicle which he has used, is one of the best means for stating these subjects so that they may be comprehensible in terms of human feeling and interest.

Mr. Noyes comes to us, then, as a scientist, a philosopher, a man of letters, who has chosen poetry as his medium for expression. He is a forward-looking man. Recently he said to me, "This is a critical period; I hope something may be done about it." His paper will give you a point of view looking out upon spiritual values as they touch the university and the social order.

Conference of universities under the auspices of New York University, New York, November 15–17, 1932. *The Obligation of Universities to the Social Order*, edited by Henry Pratt Fairchild, pp. 351–352. New York: New York University Press, March 1933.

THE BREADTH OF AN EDUCATION

Without offering an explanation of the situation it is clear that in these days an education is considered an asset. A recent statement on the value of learning indicates that less than one per cent. of the population of the United States has the benefits of higher education and that at least fifty per cent. of the leaders in the major activities of the country are derived from this small group. The same statement suggests that a person having only an elementary education has a chance for real success somewhat less than one in forty thousand; with a high school education, a chance about one in sixteen hundred; and with a college education, a chance a little better than one in one hundred and fifty. A gratifyingly large percentage of the young men and women in college make the decision to attend entirely from their own initiative. In a surprising number of instances they not merely make the decision but pay the bills from income secured by their unaided effort.

The statistics derived from any of the various sources available are uniformly indicative of the value of such a training as we now secure. At the same time we realize that there is a large waste of effort both through failure on the part of the student to understand the purpose of education, and failure of the educator to transmit in the best organized and most intelligible form the elements of the subject which he represents.

The body of knowledge made available by a university is as wide as the range of learning and necessarily concerns not merely what is known but what should be known and will become known by use of methods not yet devised.

Our present knowledge represents the inheritance of all data made secure within the present cycle of civilization in books, manuscripts, architectural and engineering structures, habits, social customs transmitted without record, and everything that pertains to the life of human beings or to their environment. The bulk

Founder's Day address at the University of Virginia, April 13, 1922. *University of Virginia Alumni Bulletin*, ser. 3, vol. 15, no. 3, pp. 268–274, July–August 1922.

of learning is very large. In the city in which I live there is a library containing about four million volumes. Presumably everything in this accumulation is of value from very many points of view. No one can comprehend or scan it all. A vast mass of other knowledge has no representation whatever within the scope of this library.

The problem which faces the student and educator consists not alone in recognizing the value of the elaborate detail of available information, but in learning also the fundamental principles through which it may be presented as a simple comprehensible reality for use in shaping our life work.

The aims of education may be stated in terms of many kinds of classification. It is necessary that everyone related to education, either as student or instructor, should have a mental picture representing the whole range of purposes. I have generally thought of education as including necessarily five principal objects which are—the determining of individual capacity or adaptability, accumulation and organization of information, training of judgment, development of creative ability, and the forming of character. It is not, however, of these several aims that I desire to speak but rather regarding the range of information or the breadth of understanding which seems necessary in an education so balanced as to give the largest chances for success in life.

To one who wishes an education the first requisite is the quality of open-mindedness. Without the attempt to review and accept information in the spirit of fair judgment—without willingness to recognize truth rather than substitutes which may for the moment seem to us personally more agreeable, it is a waste of time to spend effort upon training or learning for any purpose. It is immaterial whether this attempt to learn is made through aid of regularly established agencies for education or in the routine conduct of daily life, if the mental eye does not picture knowledge as it really is, the result is illusion and unreality, with all the misunderstandings and dangers that such a condition must bring through creation of an unreal world inhabited by people who are not what they seem to be.

It is possible to go through life with little visualization of what there is about us and with practically no philosophy regarding our surroundings or the role which we play in them. Each of us

inherits from a long chain of ancestors sufficient physical and mental equipment to keep us going for a considerable time without much beyond automatic action in response to the tremendous stimulation of life about us. Much brain work and apparent intellectual activity has in it little of individual effort or initiative beyond that typified by secretion of gastric juice in a stomach in which food has been placed. The person who attains true individuality and graduates from the class of automatons is compelled at once to direct individual action by knowledge of the realities in the physical, mental, and human world about him.

How little of reality most men know—how little any one can know—is illustrated by the daily record of human failure in attempts to solve great human problems, economic, social, and political, that are of vital concern to us all. An education aims first to tell us in simplest language the truth about what we are, about the world in which we live, and what we may naturally expect of ourselves in these surroundings.

Open-mindedness does not mean continuous doubt or distrust, it merely accepts things for what they are and recognizes new information for what it may be worth. It is conservative in that it holds fast what represents reality, and progressive in that it receives new truth continually and gives it the proper relation to existing knowledge.

We can have no better illustration of open-mindedness than that given by the wide contacts of Thomas Jefferson with fields of knowledge and investigation ranging from organization of human society to the ultimate meaning of the earth and the environment in which we live. Some of the best evidence of Jefferson's ability to accept facts for what they are is given in his paper published in 1797 presenting the first study of an extinct vertebrate or backboned animal in North America. These bones were secured from a cave in Greenbrier County. They were seen to represent several parts of a skeleton, including an enormous claw unlike anything which he was then able to find for comparison. Strange as the specimen seemed, Jefferson did not call it a concretion, a chance resemblance of rock to bone, or a reject thrown aside by the Creator in building the world. He did not hesitate to say that these odd fragments represented an animal that had truly lived, and wrote: "In fine the bones exist, therefore the animal has existed."

Just as Jefferson drew lessons from the fossils and the rocks so he attempted to understand and interpret a wide variety of phenomena and conditions about him, and among other ventures carried out a study extending over thirty years on the languages of the Indians of America. Thus it came about that his judgments upon the great and immediate human problems of the people whom he helped to govern were made with a perspective which did not permit superficiality, immediacy, or personal interest to swerve him from what seemed to be true interpretation. A spirit of inquiry made it possible for him to recognize that gaps exist in knowledge and that constructive effort and unbiased judgment are absolute requisites if these spaces are to be filled.

The immediate purpose of an education is to give the individual a range of action through any or all directions in which his interests may lie. In the time sense, the objects of education do not concern the immediate future of the individual, nor do they concern the individual alone. The young man who takes up his life work having passed through grammar school, high school, university and a post-graduate course, has not given this time and preparation especially or specifically for the years immediately succeeding separation from college. If this were all that is concerned, apprenticeship in a practical business would fit him fully as well for these particular years. To one attaining the age of graduation, say at twenty-two, life insurance companies give an expectation of a further long period, of which at least half is subsequent to the seven years following graduation. In other words, the time of maximum activity and capability for interest, enjoyment, and effectiveness in life lies mainly after such a post-graduate period of apprenticeship. The time of greatest satisfaction in work to the individual himself may lie between thirty-five and sixty-five because this is the stage of greatest accomplishment. It is mainly for this period and not for the immediate future that the student's education is planned and paid for by community or by individuals.

For this long time of maximum constructive activity it is not the details and superficialities of education that count. Problems of radio-telegraphy, radio-telephone, transportation, bacteriology, road-building, and salesmanship which may be critical at the time of study, say at eighteen to twenty-two, will be largely out of date by the time the man reaches thirty-five; but the basic principles

and laws which underlie these activities and which furnish the tools by which the great, new problems of the student's life between thirty-five and sixty-five will be solved, are derived from the fundamental studies and their wider applications which should be covered within the educational period. These foundations of knowledge will continue of increasing importance for all time.

True education must also relate in large measure to development of the attitude of mind that makes it possible for the student to construct or create, in order not merely to meet emergency situations but to assist as well in the natural development of existing conditions into the more intricate complexes of future years. We should be prepared to solve problems as new to us as radio-telephone would have been to our grandfathers and we must develop new methods or appliances out of or by use of laws which we now know as basic in science or in its application.

We must not omit to say that an education is incomplete in another dimension if there is failure to recognize that the difference between constructive activity and the lack of it may be the difference between human individuality and that type of existence which represents merely the passing on of the talent given to us without development of it in any way, and almost necessarily with impairment of value in the transfer. Some persons are not, properly speaking, individuals in the human sense. They are cogs in a wheel or links in a chain which others utilize.

We place much stress upon the idea of personal liberty and are prone to give ourselves to discussion of individual immortality without recognizing that the problem which is immediately before us really concerns individuality first of all, and is a question in which the determination of one phase lies within the power of every person. Many refuse individuality because it means responsibility. One cannot be an individual without differentiating himself from the world about him by service or by influence. Individuality means the assumption of judgments, the playing of a specific part in life. It means careful decision as to one's relation to other persons similarly situated. It goes without saying that immortality cannot exist without individuality and it might also be said that the immortality toward which many look represents merely the continued being of the individual in the self-centered sense, instead of the immortality of recognition made possible by

assumption of activities which create a place of significance and responsibility.

The qualities of greatness in Jefferson I hold in large measure to rest upon his constructive ability applied with good judgment and open-mindedness; but the range of his knowledge and the depth of his perspective gave unusual possibilities for valuing the materials which he used. A distinguishing characteristic of his self-education is found in the fact that he did not limit himself sharply to any one of the special fields of study but permitted his spirit of inquiry to extend through nearly the whole range of scientific and humanistic knowledge. He saw in some measure what modern science has brought out with increasing emphasis, namely, that the wider the range of investigation the clearer it is that physics, chemistry, astronomy, and all other so-called physical sciences have behind them certain fundamental laws which offer a basis of interpretation for the whole field of science. And so he realized again that in the principles of economic law, of history, of government, and whatever concerns the regulation of human conduct, there are basic ideas or laws without the understanding of which political effort becomes a mere makeshift for immediate purposes.

So let me suggest that in the contemplation of what should now be involved in education we require not merely the correct attitude of mind but with this the student or the instructor should have that breadth of vision which permits him through contact with a reasonable range of subjects to see not merely man but the character and dimensions of the universe in which he works as well. No education can be complete which does not recognize the need of understanding the environment in which we live, the nature of man as fully as we can know it, and something of the relations which naturally obtain in the organization of society. The breadth of an education should cover these phases of knowledge in the form of the simplest possible interpretation of the fundamental or underlying laws. We may not know the vast bulk of detail involved but we should at least recognize the principles of organization and the meaning of the plan reduced to its simplest terms. Any one who passes through a university without having come to see, and in some measure to understand, the essential facts relating to the nature of man, the interrelations among human beings, and the relation of humanity to its environment, has missed the oppor-

tunity to secure knowledge which he will often need if he is to help in solving those outstanding problems for which vision is requisite as well as leadership.

Jefferson assumed responsibility for constructive thought in nearly every field with which he came in contact. His greatest contributions appear to have lain in creative statesmanship and in education. He is characterized by the many dimensional development of his education and life expressed, first in an intimate investigative relation to the natural world about him; second, in the expression of his knowledge through scientific writings; third, through his great contribution to the organization and establishment of education; and fourth, in the application of his knowledge to the greatest of all problems, namely, that of human relations in government. No man can serve as precise pattern to all who follow. But the open-mindedness, breadth of view, assumption of responsibilities through constructive thought, and the application of it all to the human problem, in my mind make Jefferson's interests and occupations typical of the kind of vision and attitude of mind which should appear in the student who secures from an education the things which are most fundamental and most important. The ideals which Jefferson proposed for education are expressed in the organization of your University. I am sure that in the development of these ideals the plan will be recognized not as formal and fixed, but as having in itself those characteristics which make for its own improvement with change of circumstances and of human environment, and that the spirit of the University will be that of progress, made certain by your fidelity and courage arising from the desire to better all conditions for all men.

SCIENCE AND THE CONSTRUCTIVE LIFE

Endowed with a mind that may not be denied the privileges of thought, human-kind has never been able to avoid attempting definition of purposes and objectives in life. Philosophies and religions of all ages have developed in response to this desire. Although we tend to consider practical matters as concerning mainly the present, and it may seem easy to drift without defined ideals, today, as at all times, we are moved by desire to live with a purpose.

Objectives in life are determined partly by appreciation of our capacities, and in part by understanding of conditions under which we live.—To those convinced that human beings have no capacity for what is called immortality, and that there is no relation between life of today and any later life or activity, it might seem logical policy to eat, drink, and be merry, since tomorrow we die. For others, who think of all that represents the flesh or the physical, worldly life, as something to be crucified, it may appear desirable to stake everything on what comes beyond the grave.

If from any source of knowledge it were to become clear that six days of creation ended the building process, there might be no need for considering it important to do more than maintain what exists. If, however, we discover that man is constitutionally a creative being, that history shows a continuing process of development, and that future ages may profit by our constructive effort, then life today may seem to present great opportunities and responsibilities.

From one point of view our attitude is defined by influence of accumulated experience and vision of the race. On another side it is determined by the circumstances of personal experience.

Through the centuries, practically every great contribution to thought or action has influenced our views of life. Sometimes this influence was exerted by great literature, philosophy, or art, sometimes by commerce or war. So in this age of science, it appears

Founder's Day address at the University of Virginia, April 13, 1933. *University of Virginia Alumni News*, vol. 21, no. 7, pp. 153–158, April 1933.

natural to see arising a voluminous literature concerning possible influence of the scientific method upon our thought regarding life.

Seen from the side of personal history, every human life is in large measure controlled by a program of development which we are practically powerless to change. From an infinitesimal germ we develop through the stages of embryo, helpless infant, youth, maturity, and old age, all in accordance with biological laws or modes of procedure which have been hundreds of millions of years in finding their present methods of expression. When, in youth, the period of conscious human living is entered, much of the zest and joy in life derives from this continuous change to new fields of interest opened by developing strength and capacity.

Even after maturity is reached, we are involved in a process which accustoms us to change of conditions. Each person succeeds in turn to various opportunities and responsibilities. Not only money assets, but social and political power of the preceding generation are inherited. If a bank officer, or a university instructor, waits patiently, and holds his own, he becomes a senior in the business, because those who made the places before him have moved on.

So large a part of the total volume of movement in life is of this nature that it simulates in a manner the operation of a mechanical stairway, with upward movement of the individual attributable to operation of forces over which he seems to exercise no control.

But, in reality, over the ages mankind has progressed. The total cultural value called civilization has increased in variety and usefulness. This means that the mere inheritance of opportunity and responsibility requires increasing effort. Merely striving to maintain what has been secured imposes a requirement of concentration adding to the zest of life, and introducing a selective element in succession to positions.

Accumulation of values which collectively make our culture or civilization can be explained in part by accidents of discovery. Whether or no Charles Lamb, in one of his interesting essays, was correct concerning the origin of roast pork by having the house burn down with pigs in it, this type of discovery has occurred frequently. But the principal factor concerned in our advance has been the inherent intellectual curiosity and building instinct of mankind.

It is these higher qualities that have given us opportunity for

progress in all aspects of cultural achievement. In a most fundamental sense this is the striking character that distinguishes man from the universe of things and beings about him. It is this quality that makes possible almost limitless achievement, and, in its creative aspect, represents the highest attainment of mankind.

With special emphasis at particular times and places, constructive and creative effort have marked the history of man through all stages. The first tool-makers increased effectiveness of human hands, the architect, in giving permanent shelters, produced the framework of social organization through defining the necessity of human adjustment and co-operation.

Great creative concepts arising from the imagination have been developed by the mathematician, engineer, architect, artist, musician, poet, philosopher, theologian, student of social and governmental organization, and in many other ways. Continuing development of language, giving bettered form to thought and expression, was one of the greatest of all creative works.

In past ages each of these types of activity, from engineering and architecture to philosophy, stimulated in the people of its day an interest in creative achievement as giving exceptional measure of satisfaction and recognition. Each in its way moved the individual mind, and the collective mind of society, toward clearer appreciation of objectives in life. They also aided in defining individuality of the workers. Through understanding of this situation mankind has been led to shape its course, in considerable part, by desire for achievement or realization of ideals.

The world today furnishes at the same time the results of all the many accomplishments in constructive and creative work. Also it presents them in such relation to each other that they are seen as supplementing parts in a unified scheme of knowledge.

Among the outstanding features of our own age there can be no doubt that some of the most striking owe their existence to influence of what we have called creative or constructive work in science. Although the method of science is not new, and it is not necessarily the most important type of constructive effort, it has affected the structure and purposes of society so profoundly as to warrant recognition as one of the great forces in history.

While in some respects the scientist is better described as discoverer or explorer than as builder or creator, modern practice has

accustomed us to speak of scientific work as constructive, and sometimes as creative.

Science in its earlier phases seems to have been in large measure a classification aspect of knowledge. Modern methods gave, as it were, new eyes and new modes of analysis. The old boundaries of perception by the unaided senses were broken through. We might have been created with x-ray eyes, or apparatus for perceiving cosmic rays. But such means of observation were left to discovery by the mind. Modern investigation has opened unbelievable vistas into the so-called natural world, into the power and energy about us, and into past time with its changes and their consequences. The molecule, atom, electron, our own solar system, the spiral nebulae, the marvels of microscope, telescope, spectroscope, have all contributed to the picture. At times, it seems hard to believe that before the recent epoch of discovery the wonders of nature were all here—ready to be inspected, but without our knowing it. Modern advances have also modified materially our views as to what the universe really is. We know that the limits are not reached in any direction, and naturally inquire what lies beyond.

What has been brought into our lives by science really represents two types of contribution: one comprises the newly found realities discovered in nature and in ourselves; the other is represented by an attitude of mind or a method of approach.

What is given us in the infinity of new views of nature opened by science is a tremendous factor in life. It is not possible to think of the new universe of quickened atoms, of incomprehensible space, or of inconceivable time, without holding up to this background our ideas as to place and purpose of the individual.

In a comparable sense our views of life are modified by what may be called the method of science—that is, the idea that decisions must rest upon facts, and that in the search for knowledge and its logical use lies the foundation of safe living. What is called investigation or research is only the expression of this attitude of mind.

We seem to be approaching a stage in everyday affairs, as well as in science, where we question the judgments of those who do not have fully open minds, and who have not at least felt out the borders of knowledge. The teacher who has not experienced the subject or problem he describes is not a certain interpreter or guide. Whatever

else may be involved in education, an understanding of the spirit of inquiry and of construction is essential. In the same way the doctor can never be wholly safe until each case becomes a special case and all obtainable information is brought into use.

Conditions in all of life are so complicated and continuously changing that no rule of thumb method can ever suffice wholly. Only the method of continuous, honest inquiry can give safe guidance. The financier who once advised you to buy a gilt-edge bond, "put it in the safe and forget it," now states that there are no securities that one may lay away and forget. All must be revised in the light of continuously changing conditions, with the spirit of inquiry and high quality of judgment essential.

One of the interesting findings of science is that isolated facts or groups of facts instead of giving reality may, by reason of lack in relationship to other facts, represent a high degree of unreality.

In many ways constructive science has tended to increase rather than to diminish values attributed to that which rises directly out of human imagination.

So far as human problems are concerned it is essential for science to recognize the "human" view as itself a reality to be reckoned with. As indicating one aspect of this situation, I quote the following lines from an editorial in the great English journal Nature: "Reason alone may be an incomplete guide for the control of human affairs and lead us into a tyranny which becomes intolerable to human nature because of its disregard for human values."

Modern scientific philosophy demands both a universe without and a world within. The atom and the spiral nebulae we know are not just imagined. Nor can we set aside as unreal the early history of this planet with its Cambrian seas, the dinosaur, and the sabre tooth. At the same time we may not deny to each person the influence of ideas that arise from conditions producing his mental states. The Governor of Yucatan, who, in speaking to me of methods for handling prisoners in a penitentiary, asked "Shall we punish, educate, or operate?" recognized a great truth not too often given its full value.

Science has shown us also the intimate relation between what has been, is now, and will be. Whatever the so-called evolution view may be found to mean ultimately in biology, it leaves us with a

world in which we recognize continuity of program, and tendency to advance in complication and understanding, which is sometimes recognized as progress. All of these elements the scientist must consider together.

Under modern views of science we have a more vivid assurance of the nature of the universe, and of possible attainment in life, or its ultimate influence, than has heretofore seemed possible. There is also recognition of the fact that nothing in life may be cast aside wholly. Things that once seemed sources of evil, and worthy only to be destroyed, are now accepted as parts of life, each in its place. Whatever advance we make is by process of balancing values and through evolution. Humanly this is not done by throwing aside the old self, but by building upon it.

The net influence of such a situation upon our objectives in life is to give increased value to effort designed to build forward, with more, and not less, respect for and confidence in the world of things both about us and within us. We acquire increased faith in the elements with which we deal, and lengthened hope for what may derive from them.

At the same time let there be no misunderstanding regarding the fact that science does not pretend to visualize either beginnings or endings. It has only faith, on the basis of value in that which can be visualized in space and time as we observe it.

It has not been the purpose of this discussion to indicate that science is to be looked upon as in any sense covering the whole range of constructive thought or activity. Illustration of this particular mode of thought in our own age is used partly because it represents a current attitude of mind, which may exert deep influence upon ideas as to trend and purpose of life. Partly it has been presented as a means of approach to consideration of one of the most important ideals in life, namely, the view of the builder with hope for the future. However you may interpret the Tower of Babel and its makers, it represents a continuous urge to form new structures in the hope of satisfying human desires. Ten thousand years hence, in similar way, they may describe our strivings to find something which can lift us out of present woes. Science is assumed to represent only one aspect of constructive life, which through its influence may have wider reach than commonly has been assumed.

In the sense of producing things which had not existed previously,

many activities of earlier periods were, perhaps, more clearly creative than modern science, so far as specific achievements of science are concerned. It is commonly when invention and engineering application come to use results derived from science that truly creative work appears.

Let there be no doubt that science can proceed only by aid of mathematician, engineer, philosopher, artist and teacher. Without philosophy science is only pieces of things ready to be put into a building. It is of course also true that without the explorer or searcher for facts there can be no advance of science, but these two statements are not mutually exclusive.—Without the interpreter and applier science does not attain its mission. Perhaps engineer, poet, and preacher are among the greatest and most truly human interpreters.

With all its achievements, science can occupy only a humble position relative to other types of contribution. Outstanding in the world's work are the accomplishments in social and governmental organization, the evolution of mathematics, literature, the fine arts, and religion in its manifold forms. In constructive or creative work, contribution in these several fields piles mountain high.

And yet, having recognized the value of all other creative effort, there is reason to suggest that, fitting itself to these many forms of activity, constructive development of science has future possibilities so important that they may go far toward moulding the future of mankind.

As has been pointed out, these possible influences include the scientific method, which requires facts and their orderly arrangement. Often the quest can be only through meticulous, penetrating, insistent effort to find things that might be considered small, with the hope that they may explain other elements which we recognize as highly important. These influences arise also from the knowledge that we are able to reach through space and time, beyond walls that have not seemed penetrable. This view of the outside world, and of the nature of man himself, corresponds to conceptions once classified as being only in the realm of fancy.

With these influences of science there should also be mentioned again the realization that logical development of scientific thought indicates a continuity of events placing man in a scheme of things

stretching from an almost infinitely remote past through the present, to a future which is not defined, but which must hold its relation to present and past. We are, as it were, partners in past, present, and future. In this relationship we see a movement or development of events that rests upon what has been considered a constructive process.

It is important to recognize the future of science as intimately bound up with that of the other great aspects of human achievement. So close is this tie that these phases of knowledge must be looked upon as interdependent.

The thread of interest in constructive living runs through all human effort. While we never see fully what it means, as knowledge progresses the tendency to movement, or to advance, in the world about us becomes more clear. The idea of having part in a great program becomes increasingly important. Small though it be, there is dignity in such relation beyond any other purpose or end.

To determine what the part shall be for each person is one of the great tasks of the future. Education must give perspective, with broad vision of the entire field, and at the same time help the individual to his place or opportunity.

What remains to be done in the future is greater than the past has ever visualized. What do we yet hope to know regarding the so-called material universe, concerning life, man as an individual, disease, government, opportunity for joy of life?—All are still to be understood.—What is there to do in literature, art, the simple life on a high plane? What greater world could one present for conquest, what more wonderful adventure, what larger reward?

When we consider that human-kind secures its satisfaction largely in movement or growth, it is clear that, unless this is to be obtained merely through accumulation or through the destructive pleasures, recognition must be given to the constructive aspect of life. It is something more than merely "growing up" in the sense of human maturity, or succeeding to positions by "seniority" as superior officers die, or "coming into money" by inheritance. In such a life is to be found the opportunity to leave the world better than we find it, to build something into the structure of knowledge, or government, or means of maintenance of life, or ways of normal enjoyment. Those who leave the world better than they find it,

and do not at the same time escape the burdens as well as the joys in doing their part in maintaining and educating the race, are the ones who truly live. Whatever other aspects of continuity in influence of the individual may be found, these, at least, live on through the ages.

"It is said that geniuses are born, not made; but those who come into the world to live non-contributive, purely individual lives, leaving the world no better than they find it, may be only made, not born."

We remember that the Great Teacher explained to Nicodemus the Pharisee: "Marvel not that I said unto thee, ye must be born again." With all the spiritual meaning that this saying carries, may it not suggest to us also that constructive service gives, with a sense of reality, a new and true life, a verifiable personality or individuality in the kingdom of creative beings.—What greater work can a university perform than through its culture, its vision, and its constructive power to open the way for that kind of service which brings the joy of progress and the continuing rewards of real accomplishment?

Founder's Day at the University of Virginia is an occasion of especial appropriateness for considering the idea of constructive effort as a dominating purpose in life. Among great characters in history, Thomas Jefferson represented an attitude of mind combining in unusually intimate relation the creative aspects of philosophy, art, engineering, science and the study of social or governmental problems. His contributions to science, as I see them, are evidence of a breadth, a depth, and a penetration of vision influencing every phase of his work.

In his undertakings Jefferson combined exceptional use of the constructive aspects of science and art with knowledge bearing upon the ultimate human significance of his problems. There can be no pattern better calculated to direct attention toward high purposes in living. Of the ways in which he influenced this University in its beginnings, none exceeded in importance the imprint of his ideas concerning creative effort as an interest in life. Through continuing contribution by your great institution of learning, devoted to truth and to progress, the example of this truly constructive life will never cease to point the way toward knowledge, enlightenment, and rewards of the builder.

CHARTS AND COMPASSES

When Columbus sailed from Palos in August, 1492, he had just enough of vision regarding his objective to nourish a germinating hope, and little enough of assurance to make the chance of his voyage exciting. As primary features in equipment, he possessed a burning enthusiasm for adventure in the unseen world to the west, and had fairly safe means of guidance as to direction through a mysterious instrument, the compass.

The navigating instrument which Columbus used was a sufficiently reliable basis of reference for direction to make possible steering a safe course across the sea. What held the needle to its position was then an unsolved mystery. And even now, after four hundred years of investigation, these influences of earth magnetism are nearly as great a problem as in 1492. We know that the forces are bound up in the structure of the atom, and that in the compass they seem to reflect a geographic or space influence concerning the whole earth.

It is interesting to note that the degree of dependability of the compass came into question as Columbus moved west. In time it appeared that the needle no longer pointed north, and doubt arose as to the wisdom of continuing the voyage. If Columbus could have obtained the complete story of this type of instrument, he would have found that not only does it change direction from place to place, but it varies also from time to time in the same place. So today at Palos, from which he sailed, the compass points about fifteen degrees west of the direction indicated in 1492.

Columbus moved out into a new world which seemed a natural extension of the region in which he lived, and yet it was veiled and mysterious. In some respects, his vision of the unknown geographic region to be traversed corresponds to the order of experience facing youth, as it adventures into new regions of time. In neither case is the transition abrupt. The flood of years just ahead does

Commencement address at the Carnegie Institute of Technology, June 12, 1933. *Carnegie Magazine*, vol. 7, no. 3, pp. 75–80, June 1933.

not appear to present possibilities more different from those of the moment than were the waves that danced under sunset lights of the western ocean unlike the sea from which Columbus sailed.

At the time of this historic voyage uncharted geographic regions were made relatively safe, so far as direction and points of reference were concerned, either by the dependable courses of the stars or by the mysterious power which held the compass needle in position.

Uncharted time, as we look out toward it, may seem less mysterious because we have possessed and used time in many most matter-of-fact ways. And yet there is no mystery greater than that embodied in what the coming years hold, and how we can meet what they will present.

The specific purpose of my remarks today concerns the problem of guidance and lines of reference available on this excursion into time. What, for example, could one say regarding possibilities of direction and guidance in time comparable to that furnished for geographic journeying by use of the mysterious but effective means available in that kind of exploration? Are we to find for movement through time instruments or principles that are comparable to those which orient us with reference to direction in space? Shall we be able to discover means of determining extent to which changes are to be expected? Are we to find that, as in geographic adventuring, such guidance and determination of direction may come from things that are mysterious and yet reliable for special purposes?

Some may assume that the program and laws of civilization have been so satisfactorily laid out that, rather than a compass for steering courses in uncharted regions, there is need for means of breaking away from fixed lines of travel. But the story of time as we know it does not support such a view. There may be reason to expect more range of variety and extent of change through time than would be met in journeying up and down the seas. Over the ages the unexpected and untoward experiences of mankind have been so numerous that one properly inquires whether we have given full recognition to guiding influences and points of reference as means for aiding that development or progress in which we profess to be interested.

The possibility of furnishing adequate guidance for mankind and his civilization through the ages depends upon ability to attain suc-

cess in two extremely difficult tasks. One involves discovery and formulation of instruments or principles making possible an appreciation of the major forces of both the continuing and the changing types as they operate through time. The other problem concerns the means for cultivating in the stream of generations, as they pass, a true understanding of these principles and their human significance.

The first task is a responsibility of the investigator. The second relates to education. On this occasion I am concerned principally with the second phase of the question. And specifically I am interested in the point of view which may be taken when one passes from the more formal education of the curriculum to the stage of self-education and experience of later life. This is the status of graduating classes at the moment.

The relation of education to this question of continuity in guidance is illustrated by consideration of the major educational influences to which you have exposed yourself in these recent years. For use in this discussion you may consider education as having, among other purposes, four outstanding objectives:

1. To aid you in the effort to know yourselves well enough to judge your capacities and your future opportunities.

2. To help in developing initiative and constructive mental power.

3. To make available such facts from the vast accumulated store of knowledge as you can use to advantage in your chosen activities.

4. To give the power to profit by values of experience and wisdom as tested through the ages.

Of these several attitudes in education, the first, relating to capacity, presents difficulties, but commonly the answer is given through expression of personal interest in the work for which one is best fitted.

The second concerns development of ability and love of constructive work, without which life would be stale and dreary.

The third represents routine accumulation of facts, as grist for the mill arising from materials furnished by the first two purposes.

The fourth objective concerns the nature of continuing experience, with values derived from age-long human judgment. Without the contribution derived from this view, each generation, for

the time of its ephemeral existence, would begin over again the task of coming to know the significance of the infinitely complex and changing universe of things and of people in which it lives.

The possibility of passing over to each generation the values of judgment or wisdom of the ages regarding this changing world is the most difficult and perhaps the most important problem of education. It is the most difficult because it represents aspects of vision concerning what is derived through actual experiencing of changes in time, such as youth can have had only in small measure. It is perhaps the most important because it relates to the purposes and accomplishments of living. To be sure, life can be lived without such approximations to knowledge, but it cannot have that definition of aims or objectives which seems so clearly essential to satisfactory living.

Some years ago I stood for the first time on the summit of a great pyramid rising above the jungle in Yucatan. As far as the eye could reach across the plain were groups of shattered and decaying buildings, ruins of a vanished civilization. Here and there were humble dwellings inhabited by descendants of the builders and artisans who framed and used these ancient cities. A friend standing with me said he was impressed especially by the depth of a great silence. My comment was that this vision of the jungle, engulfing a vast wreckage representing splendid accomplishments in architecture, art, human organization, religion, gave overpowering appreciation of what happens when education is completely interrupted. There remains in that region today a vigorous and capable people, lovers of the finer things—but the charts, plans, ideals, visions of what might be accomplished, the accumulated experience and wisdom of ages, are gone.

But where, as in our own land at present, the currents of time and life flow on without serious deviation or interruption, the significance of possibilities such as those illustrated in the Maya civilization of Middle America have little weight. And sometimes, carried by the momentum of elements moving around us, we may hold to the mere superficial appearance of things, giving little attention to the greater instruments and principles which, like the compass on the voyage of Columbus, can give points of reference and direction, without which movement may become aimless and progress only a matter of chance.

What would happen if with us education were stifled for but a single generation? What that is now carried along continuously represents elements that are essential to such progress as we observe?

Today we stand secure in the feeling that the structure of civilization may not be broken. Such has probably been the attitude in every country which suffered a fate like that of the early American culture. How safe are we today in spite of science and education? Can we forget that it is only a few years since in the mad rush of wealth accumulation it seemed as if in this country some believed the mathematics of business in which two and two made four to have been set aside, and that, under modern conditions, two and two made five, or seven, or nine?

Now, as always, the real questions concerning security are not to be answered by consideration of that infinite group of superficial details which to many may represent life, but which time proves to be only surface gloss. It is a strange phenomenon that much of what is most important to us we come to know commonly through abnormal conditions. It seems almost necessary for us to be ill before we give attention to what constitutes the requirements of health. This is true not only of digestion and circulation, but of our mental, social, and spiritual well-being also.

It frequently requires what we call a "jolt" to make us aware of digestion or social responsibility. We seem to need such an experience as the vision of an extinguished civilization to make us inquire regarding security as to structure and course of that human organization which we help to build.

Considering the progress of civilization from a somewhat different point of view, it is sometimes said that our advance may represent any or all of three methods.

One is just chance; a second is permitting nature to take its course, on the assumption that there are underlying natural laws that will carry us forward slowly, surely, and perhaps at great expense; a third method is by guidance through use of our intelligence.

That "just chance" rules the world is to most persons expression of a state of mind that indicates either lack of vision as to what exists, or a special use of the word "chance."

That, according to the second method, great laws or modes of procedure underlie and guide the movement of events in nature about us, in the history of man in early stages of his development,

and now in the period of our awakening, becomes increasingly clear with careful examination.

That, as the third possibility, human intelligence can plan progress over the years beyond is also evident, within limits which seem to widen as interest and attention in the problem deepen.

It is also increasingly clear that planning the development of our world, and of man in it, can succeed only where adequate attention is given to those great principles which underlie nature and human life. Much of what we have erroneously thought to be advance has taken place with little regard to what the world and man really are, and without recognition of fundamental qualities and modes of growth established by milleniums, or by vastly longer periods of development. The record of man's work as assembled in history is only too largely a succession of shattered hopes, unfulfilled desires, broken treaties, and suppression of movements designed to accelerate progress. Out of the accumulating heap which represents the past we have surviving values of a few features continuing with unabated influence.

With special reference to the problem of charts and compasses and guides, both for civilization and for the experience of this graduating class, it is the relations of chance, great principles or laws, and the application of intelligence that I have particularly in mind.

Of the principles seen in the natural development of life, we may think of one class as operating through long periods as stabilizing agencies, and of another group which expresses methods or modes of change. The first, like gravity, may hold the world level; the other, like evolution, may indicate that it will change and in a particular direction.

The task of determining what are stable and dependable elements, and what are indicators of changing conditions, presents almost infinite difficulties, but real progress has been made. Perhaps we do not know more regarding the true or fundamental nature of these features than has been learned regarding earth magnetism and the compass. But there is in them evidence of reliable guidance through time comparable to that of the compass for use over the seas in space.

To present a discussion of all instruments or conceptions which might serve as compass or chart through time would require a compendium of general knowledge. The idea may be expressed

through illustrations which your own knowledge will extend. From the broader field of science, I have no hesitation in stating that the principle of development, or evolution, beginning with the origin of stellar systems, reaching through vast ages covering the story of this earth, and leading into development of human life and institutions is one of the greatest aids to vision that knowledge has yet produced. Microscopes permit us to peer into infinite littlenesses; telescopes give us views across great stretches of space. Broadly conceived, evolution is something which shows us the movements in time, and presents also suggestions concerning the future which intelligence cannot avoid.

Twenty years ago H. G. Wells published a little book, "The Discovery of the Future," a document of compelling interest based upon this principle. I am moved to quote the following lines: "We perceive that man, and all the world of men, is no more than the present phase of a development so great and splendid that beside this vision epics jingle like nursery rimes, and all the exploits of humanity shrivel to the proportions of castles in the sand."

From the point of view of fundamental vision in human relations I would recognize the Sermon on the Mount and associated documents as one of the greatest guides for future conduct. To me it is not merely a point of view in religion, but is a statement wholly sound in ethical principle, in definition of effective human relations, and one following closely our fundamental scientific conceptions.

I would place the principle of individual liberty, basing itself upon self-respect and constructive ability, as properly something in support of which any sacrifice might be made and on the basis of which future civilization must in some measure rest.

Let there be no doubt also that recognition of responsibility to the community, with the principle of human service, represents a phase of relations which is of infinite value for the future.

And, for the inner life, there can be no question that the basic principles which have dominated great art, great literature, and the great religions, if given opportunity for adequate expression, are among the most fundamental interests both for stabilizing and for development of effective and satisfactory human living.

One of the problems in use of such features as have been described, lies in the difficulty of making clear to those having as yet little opportunity for experience how important these findings may be. Much that you as students have received in education will

not begin to obtain its value until through the illuminating and inspiring influences of contact with realities in later life you come to appreciate the meaning of what has been said or done.

Some of your educational experiences may resemble innoculation, which can be expected to develop only when you reach a place in time or a special situation in life where your intellectual food and drink are favorable to development of that germ—and it will then grow into a culture that will aid in clarifying vision.

In education the element of inspiration holds a sacred place in which, as it were, there is passed on the fire of living souls. Under the illumination of personal contact with great realities, or through touch with minds lighted as if by fire from on high, vision awakens in you new vision, and the deeper mysteries take on clearer meaning.

But we must not forget that the relation of great principles to future voyaging is not to be considered solely in terms of civilization broadly—for the possibilities of making a living in the particular year following graduation, it is a question whether many would not seem to be in better business position had they taken apprenticeships to work their way along. But an education is needed most as a basis for building such as may become broad and ultimately high. It is not merely for the year after graduation but for all of life that one prepares. To what extent will the special guides which you select give light and wisdom needed in those later stages of life when the greater questions come to replace the lesser?

In this day of great discoveries, big business, and world politics, civilization and the individual face situations through which only the most refined vision can penetrate. Just as in the physical and biological sciences, intelligence has found the way to unbelievable attainment. So in study of man and his future I look to see developments of corresponding magnitude open the way to wider understanding, and to such a comprehension of navigation through the mists of time as may meet our coming needs.

No generation of all ages has had greater vitality, and finer enthusiasm for its task, than the one which now moves into the field of control. May its strength and its vision bring results even more important than those which crowned the efforts of Columbus in his voyage to what was then a place in the future of discovery, but has, in time, become our home.

SCIENCE AND CULTURE

MR. CHAIRMAN, Ladies and Gentlemen:

I spent part of yesterday evening in a discussion on adult education with a group of men interested in newspaper problems as they relate to adult education, and one of the matters that we considered concerned the relation of the reporter to the scientist. How far is the reporter able to go unless the scientist is able to tell him what his paper is about and the subject which he is discussing? We insisted that the scientist should make his point and assist the reporter in giving a clear statement of the contribution that he is making to knowledge.

As I came into the room this evening, a reporter met me here at the entrance and asked me what my subject was and if he could take my manuscript. I said that my manuscript was in the same class with that fire on which you remember the clothing storekeeper was congratulated, which story I use to illustrate a point. He was congratulated on the fire he had last week, and he being clever and having studied the Einstein Theory, said, "That fire isn't last week; it was next week." And I sometimes prefer to write the paper after I have made the speech, and then I am sure they agree.

The reporter said, "You are talking on 'Science and Culture.' What has that to do with adult education?" My reply was that when the honorable Director of this Association gave me the subject, "Science and Culture," he knew I was an evolutionist, and he was quite well aware of the fact that a man who is an evolutionist never makes a speech without coming around to his pet subject. Someone said to me a few days ago that I ought never to attempt to talk on purely philosophical subjects but always stick to my own problem. I replied that if he should take a cat and drop it from various heights along the wall, four feet, eight feet, sixteen feet and twenty feet, the cat would always fall on its feet, and that

From stenographic record of an address before a general session of the ninth annual meeting of the American Association for Adult Education, May 22, 1934. Abstract in *Journal of Adult Education*, vol. 6, no. 3, p. 324, June 1934.

if a scientist, an evolutionist, doesn't come back to his subject several times in the course of his talk, it is prima facie evidence he is not an evolutionist. He must be some other kind of person. So the Director of the Association knew I couldn't talk on science without referring to the fact that science and evolution are related to adult education in that adult education has to do with a developing process.

According to evolution, we live in a world subject to change. It doesn't come back to the same state, it goes on and on and on. We have tested it out for a billion years or so and we don't find variation from that rule. The scientist believes also that this same process affects the life of the individual, that it goes on and on; it doesn't stop, so far as education and interest in intellectual things are concerned, with graduation.

I have been much interested recently in attempting to see something of the trend of thought over the ages with reference to the kind of thing that is in the air at the moment; namely, has the world gone wrong completely? Has human intelligence led us to the edge of a precipice over which we shall shortly be pushed? Every time I study this as an evolutionist, I come back to the fact that the earliest literature at any rate with which I was acquainted, whether it was the first written or not, makes the suggestion that two people who were the first inhabitants of this earth were put out of this delightful place because they thought they knew too much about the situation, and they had to go out of Eden and work to make a living. So I am helping today to interpret the social side of science in this world.

I received today a request to write an article in a symposium on the question, "Is science wrecking the world? Do we know too much?" The same old question that is involved in the story of the Garden of Eden, and all the way back through the ages this has been one of the questions at the front.

My comment on this is that it is in the nature of the case. Now if you take almost anybody in this room and give that person four large drinks of whiskey you expect a changed attitude toward life. It will work in different ways. If you take almost anybody in this room and turn him over to a skillful student of brain and endocrine, and so forth, and let him perform an operation, the intellectual process will cease. The best statement I ever heard, which

some of you have known me to state to you, is that of the very Red Governor of Yucatan who some years ago, standing with me in front of the penitentiary at Merida and speaking about the prisoners said, "Dr. Merriam, the problem is, shall we operate, punish, or educate?"

So I should say, the trouble with the world is that a kind of being has been created that has in it that something or other which I am not going to discuss in the presence of philosophers and probably anatomists, and probably even endocrinists, and so forth. It has in it something that gives the urge and this urge pushes on and on and on. The poets have stated in all sorts of ways the way we are pushed by that thing within. My own feeling is that that urge expresses itself whenever there is an opportunity. As a scientist I have never been bothered about attempting to get an education or develop an interest in anything. I have merely faced the things and have been interested. That is not my fault or the fault of the things in which I have been interested but it is due to a situation in which I have been placed with this urge.

I ought not, perhaps, in the presence of this group to go farther into educational matters, but I will this once and say I have a great many friends who think that unless we are careful with the instruments that we are using, organized education putting down the clamps may be the thing that stops the interest of people in things about us and before us, and one of the great questions today is, how can we educate without taking people out of that stream of thought which leads them to interest when interesting situations arise?

Now the relation that my question of science and culture has to adult education is that I believe both science and culture to have a very important part in that developing life of the individual beginning with the period of graduation, or I hope before it. The point that I wish to make, and which I gave to the reporter, is that I am a good deal concerned over the tendency of extreme specialization in the world at this time: too many scientists who are interested mainly in science, and too many who are concerned with just culture; who look upon culture in the restrictive sense, in the passive sense, in a limited sense, rather than with the broader view which I like to see as representing culture.

My own concern is that we develop the right relation between

that peculiar urge of science at the present moment and that broader vision of knowledge which is represented by culture. If I were to give a definition, I would say that science is an attitude of mind which has to do with the securing of facts and their organization and their presentation. I hesitate in this presence to give a definition of culture, but, from my point of view, it is the highest refinement of our appreciation of knowledge in the comprehensive sense, it is that wider vision which represents the rounded man or the extended view of things covering all that touches the human mind and putting each phase of knowledge in its proper relation to others.

I fear to stop to say even a word regarding the development of science, because this is dangerous when a scientist is concerned, but I may not avoid making the comment that in this particular age we have reached a time when after a long period of development of science and certain aspects of its normal expression, we came suddenly not many decades ago to a time when new ideas and new methods were furnished and new worlds appeared. They had been there through the ages but we had not made their acquaintance. The telescope has opened worlds in space and we reach out farther and farther to these distant places which are now measured in terms of light years, with light traveling 186,000 miles a second and the distance it travels a year being the light year, and we have millions of light years representing the more distant regions of space.

Whether you wish it or not, there will be a continuous stimulation in the educational sense as long as new instruments are discovered which open new realms for vision and new fields for thought, and there will be adult education in astronomy as long as new discoveries are made regarding the temperature of the sun and of the stars up to millions of degrees and the distance of the farthest nebulae in the terms of light years. And education will go on through the public press and through the magazines and through lectures and through books, whether you plan it or not, if the scientist continues his work.

In the same way, if the microscope and the microscopist go on with education, discovering the innermost structures that represent the materials about us or our own bodies or life in the broader sense, it is going to be a stimulus to thought coming out of it, and

the materials of that thought are going to be applied to the most practical things of everyday life. I refer to the students of the endocrine glands, which practically are the masters of man today. You know that the students of development start with the genes and chromosomes and they carry us along for a short distance with these controls of heredity until they come to the place in the story where they hand us over to the endocrines, which carry us on through the rest of our lives. We once thought the thyroid did only this and the other glands did only that. We know now they are all working together and something else stirs up the thyroid and that does something to some other gland, and so they work back and forth controlling us, and as long as the microscope continues to show us these great worlds within worlds, there will be adult education, as I say, whether you plan it or not, if the scientist lays his materials before you.

My own particular field has lain rather in the region of time. I like to call it history. I found the other day I had written an article an editor decided wasn't history but pre-history and that present history began at the end of Pleistocene and all the humans before that were pre-history people. It has been one of my interests in life to try to look back with what others have done through these vast ages to see what has occurred in the millions of years of history that we know fairly well, and there I have seen this picture of continuous change and continuous building. From my point of view, I am more concerned about what has happened in life on this earth and within living beings than I am with the distances to the farthest nebulae. At any rate, it is more important to me, because I have come out of this stream of things, and so have you, and I am interested in knowing my ancestry, partly in order to know about what I am and what I may expect of myself during the time that I am supposed to be in command.

So through all these regions adult education over the years is going to have its important place so long as discoveries are made, first because of the stimulus to thought, and second because of the direct relation to the practical things of everyday life. If you ask what do I mean by the practical things of everyday life when I am talking about the temperature of remote stars and the way they expand and contract, and so forth, what I mean is this, that those men who have to do with power and with energy and with

some of the greatest of all of our industries, are the ones who are waiting for every scrap of information about the nature of matter that comes from the studies made with the telescope, the spectroscope, and other instruments that have to do with what is going on in the stars. If these things happened to matter in the stars and to matter of the same nature that we have on this earth and our sun, then we may modify our path in accordance with what we know can happen under specific conditions. So it is all practical in that sense.

Now if I may turn back to culture, where again I walk with careful step because I know you are students of culture and I am only a paleontologist or student of science, there is one comment I wish to make. Culture from the very nature of the case must be expected to be conservative. It is that view which shows us knowledge of various aspects, each phase in relation to the other. It is something that gives us a balanced view, in which we have a balanced judgment concerning the significance of the various aspects of knowledge and their meaning to us; a view that may not easily be destroyed and should not be destroyed. Religion must of necessity be a conservative thing because it represents the foundations of belief, and while beliefs change they may not be destroyed overnight without endangering all that rests upon them, and there is much that stands upon the foundations of belief.

There is a danger, however, in culture that it be too conservative. There is no finished chapter or closed book. Knowledge always goes on and culture must be expected to receive from time to time new things to add to its general scheme, and after all, culture must be constructive and not passive. It is the man with balanced judgment who sees the world as it is, human beings and our surroundings, with everything in its place. It is that man whose judgment is most important, but it must be constructive and not destructive or merely passive.

Ideals which grow out of these situations and these visions are forward looking things and not just backward looking, so I see culture as a constructive thing that represents the wider range of interests involving perhaps science and all that it presents to us.

I may stop for a moment to say that it is impossible to be a scientist and to see the reach and extent of knowledge as it is visualized from the position of the scientist without going over into the place in which the student of culture stands. It is my own

view that these two representatives must walk in step, if not hand in hand, if we are to have a balanced world in which the judgments are of the highest type.

The point I wanted to make to you is that for the future of man, we must have more fact and we shall have continuing discovery and continuing increase of fact, and it must be properly organized and the scientist must see that his materials are placed where they will do the least damage. I have full sympathy with those who criticize scientists for bringing unbalance into the world, because I believe that unless the results of these discoveries are handled with care they may drop into places where without adjustment trouble will arise, and it is part of our task to discover and part of our task to see that the results of discovery are so used that they do a minimum of injury.

It must also be true that, as time passes, that balance will bring us a better and clearer philosophy, which means a penetrating vision into all that science and culture represent. We must have more reverence and better and clearer and better founded religion, which will also go through a process of evolution as knowledge widens. And so culture and science side by side, science perhaps the stimulating influence and culture the balancing influence, must work through adult education and more may be done in the adult stages than is accomplished for the youth. As a student in the university, I was impressed by the fact that science leads to truth and that culture leads to art and to beauty, and that truth and beauty are two of the things which are the most fundamental influences in life. There are many who are not able to see that truth and beauty have relation. However, the philosophers here will tell you that this began with the Greeks or earlier, and has been covered by song and discussion down through the ages.

Only a few months ago I picked up an old copy of a University of California magazine, edited by a mathematician, a magazine that up to its death quite recently was devoted largely to poetry, and I was interested to find that a student concerned with research was willing to take the time to write these lines regarding beauty and truth.

> "Beauty and truth share one abode, I know—
> It is fallacy that truth is plain.
> As beautiful as mountains tipped with snow,
> So loveliness adorns the truth's domain."

It was not new—the Greeks said it, and many others all the way through—but it is exceedingly important for us today to realize that there may exist and should exist this relation between these two commonly quite sharply separated aspects of our intellectual or may I say spiritual activity.

I look, then, for the future to bring us a situation in which these two great guiding and controlling forces shall have a larger influence upon life, and especially a great influence in the continuing development of the adult. I assume that in the last analysis the most important thing that science and that culture and that adult education will do will be to tell us more about ourselves. Because, after all, whatever the world be and whatever our surroundings, if the individual is not properly geared, perhaps you would say first to his surroundings, but I would say first to the understanding of himself, then the world may go to wreck when anyone is desirous of setting a match at any one of many places. So the fundamental consideration in all of this is, what science and what culture can do combined to teach the adult to know himself and to control himself and to keep in mind the fact that he has a responsibility on two sides; one to see that he is fit and that he does his own work, and the other a responsibility to realize that he lives in a world of people to which he must be adjusted, and every individual must be adjusted to all the other individuals if we are to make the most of the world in which we have been placed.

THE INQUIRING MIND IN A CHANGING WORLD

In the immediately practical sense, the idea of a changing world is carried unavoidably in the term "the new deal," which means re-shuffling the cards and beginning again. I happen to live in Washington, where one sees the dealing intimately every day. And yet rather than attempt to discuss any special phase of this great problem, in economics, science, or government, in the so-called practical sense, I am choosing to speak in terms that are practical in the more fundamental view, regarding what may concern certain underlying principles which must be recognized where true progress is made.

I have been impressed by the tendency of education to stress knowing all about many things, whereas it is also necessary to know in many cases rather "what these things are all about." It is this aspect of knowledge that we find expressed in basic human conceptions stated in philosophy and religion. Some pride themselves on having no religion and no philosophy—which is commonly tantamount to saying that they have both, but they may be too weak to stand the test of exposure to discussion, and of little value for purposes of life.

So, in spite of the fact that I know how difficult it is to express the values of human experience to those who are just about to enter upon such experience, I am venturing to discuss a topic which we confess to be almost infinitely difficult—and yet we know that it is unavoidable in considering the greater world questions of this and other ages.

There is no problem so old, and yet so strikingly representative of our situation in this particular time, as that concerning extent to which the peculiar qualities of the human mind may be used to control the world in which we live. The idea expresses itself through literature from the story of creation to headlines of the morning papers. It involves questions touching philosophies and religions,

Address at the nineteenth commencement convocation of the Rice Institute, Houston, June 4, 1934. *Rice Institute Pamphlet,* vol. 21, no. 3, pp. 194–206, July 1934.

and relates to urgent problems of economic and political organization. In the sense of immediate, personal significance this matter concerns some of the major opportunities for constructive thought and action open to graduates prepared for service such as the world now offers.

In spite of what some may assume to be its unpractical or purely philosophical implications, there is no problem that has attracted interest over the ages more strongly than this influence of human intelligence upon the world, and its ultimate effect on welfare of the human race itself. Whatever other significance attaches to accounts of the Garden of Eden and the happenings there, it is interesting to find the suggestion that man attained knowledge making him dangerous. Lest with newly acquired abilities he might eat also of the tree of life and live forever, man was banished from the Garden and told to earn his living by the sweat of his brow.

In a manner reminding us of ancient ideas, the press of today carries vigorous arguments regarding dangers of newly acquired knowledge derived through research, or the inquiry of science. One suggested remedy involves closing the doors of that recently discovered Eden, the laboratory, where the tree of knowledge bears many kinds of fruit useful for sustaining and healing of the nations.

In its earlier interpretation this exceptional ability, or knowledge, possessed by human kind may have been looked upon as intuitive. At the present stage of history it is the influence of inquiring, investigating minds, with their capacity for accumulation and organization of information, that causes us to consider carefully the results of human activity upon world processes.

According as conditions vary, we view this difficult subject with reference to influence of man's activities upon the world around him, or upon structure and function of society, or in a practical sense upon opportunity of the individual. Always we recognize the fact that there reside in human kind peculiar qualities and powers, the use of which represents both responsibility and opportunity.

Seen in still another light, we note the possibility of important difference in the influence of man's special qualities as between what might happen in a static world compared with one undergoing change. In early references to this question it can be assumed that the world was seen as in effect a completed work. But in the vision of modern knowledge our universe appears as a rapidly changing

panorama. Viewed with respect to these conditions, it is natural to inquire whether possibly man himself changes or is modified by influences about him, or arising indirectly through his own activities.

Both scholars and the intelligent public can be considered as accepting today the idea of a world that varies markedly from age to age in the sense of historical stages. Just as the telescope has penetrated unimagined realms of space, so intensive study in piecing together fragments of history has shown us far regions of past time, with the story of great changes experienced by the earth and its inhabitants.

To learn in early childhood that the coral-bearing limestone rocks beneath my father's house in eastern Iowa were formed on the bottom of an ancient sea, and that deposits of alien rock strewn over the limestone plains had been carried there through influence of huge flows of ice, meant for me, personally, early acceptance of the idea that this has been a world of tremendous changes.

Today no one stops to question the story of life leading back through the period of the sabre-tooth tiger and the dinosaur to still earlier ages when the aristocracy of living creatures attained no higher level than that of slimy things crawling on the shore. Also there are few who find difficulty in accepting as our ancestors those men who struggled through the Stone Age and were contemporaries of the mammoth in a past geological period.

And yet it is interesting to note that with all we know of history and its continuous movement, there are few questions more vigorously contested today than that concerning the effect upon human kind of this uninterrupted surge of change or movement in the world. Some would see man as undisturbed by it; others look upon human life as moving and changing. Stated in another way, those tremendously significant problems concerning the meaning of the great stretch of human experience called history, constitute today one of the greatest fields for critical discussion. The question has shifted from inquiry regarding evolution of nature to that concerning possibilities for advance of man.

Should we look upon the world as unchangeable, one might conceive of the influence of man's intelligence upon it as large, and the effect of his relation could conceivably have importance in determining the length of time he will maintain his existence. But with a rapidly changing world, the importance of this contact might be

increased greatly, and the period of survival of mankind shortened. Or perhaps we may think of adaptation to changes as they take place bringing advantages tending to extend life of the race, and at the same time giving new possibilities for evolution.

The dinosaur, with a brain of relatively small size, did not take thought for the morrow and became extinct. Will the human race follow the same course, or will intelligence find a way for adaptation and maintenance of its place, or will new types of evils we devise bring relatively early extinction?

So far as we are aware, no other group of organisms has found so many ways in which to widen invitation to deterioration. We have only to note that, with all of our scientific study of diet, overeating is an unquestioned abundant cause of death among valued members of society. Also with vast development of human works in physical construction and in social organization, we extend the complication of human relations in such manner as to open the way for disasters like the World War.

It will be the task of future historians to decide whether in this age man has already reached the highest possible stage of evolution in the sense of physical, intellectual, and spiritual characters. A lifetime of study devoted to subjects in this field gives me, personally, a perfectly clear picture of mankind slowly building itself upward in physical and cultural qualities through vast periods of the earlier and later stone ages. That we should accept present intellectual capacity and comprehension of man as at the highest possible level would seem to leave only the pleasures of accumulation and organization for the future. I would hope that there will not be absent from the future world that opportunity for advance that has characterized nature through all time as we know it.

Physical changes which might better our situation are largely matters of biology. But in a great number of relations this biology connects itself closely with nervous and mental activities. Whether these factors concern our intellectual opportunity, and even our dispositions directly or indirectly, it may not be necessary to assert. But we know that in practical, everyday life these relations are given large value.

I should hope that with the tremendous advance of science, physical, biological, and psychological, the future may make possible such physical advance as will give a better life and wider

opportunity for its effective use and enjoyment. What actually happens will depend upon our interest in looking still more deeply into the plan of nature; also it will depend upon the degree of wisdom in our use of knowledge secured.

What the future has in store for us in the region of social, economic, governmental, and spiritual values is again dependent largely upon our honesty of purpose, ability to concentrate attention of many workers in many countries, and perhaps through many ages, upon selection of what best meets human needs. The long struggle to find methods for organization of society which can give order and freedom, and yet secure power of the group for achievement not possible for the individual, has brought forth great principles upon which to build. The adjustments have been difficult. Swift changes in generations bring the almost infinitely difficult problem of passing on through education the results secured. Selfishness and lack of vision destroy again, and again, and again the new structures. And yet the world as a whole has probably today a better idea of how men can live effectively and with satisfaction, as groups and as individuals, than in any earlier age.

If mankind is to adapt itself to a changing world, and perhaps continue its evolution, it is necessary that we recognize the critical necessity of giving to study on organization and evolution of society an amount or a value of thought at least comparable to what has been devoted to other great works carried forward in the interest of society. But, knowing the dangers of world conflict, we spend billions on armament as compared with what might be called thousands on learning to know the means of understanding and of maintaining mutually constructive human relations. Again, if we can learn to place around great business enterprises safeguards against so-called bonanza financing comparable to those which we set up for protection of the right to hold property once acquired, there could be wider peace and larger freedom.

To make such advance as has been suggested means recognition of these facts by society and by the individual. Whatever it be called, vision or planning is essential. It is also to be remembered that according to the view expressed by those who see the world and society as in a process of evolution, the world scheme, including society and man, is itself constantly changing, and no program can be adequate which fails to take this factor into account.

Just as the critical position of this country and others at this time seems the outcome of inadequately guided or controlled constructive action, so one may look upon the present situation as presenting almost infinitely multiplied opportunity for activity designed to give the best means for adjustment and for further progress. It will be a rare field of business or government or science in which you do not find widely voiced the cry for men with creative ability, vision, and balanced judgment. There are millions without employment, and yet the need for those able to do the most critical work is not met.

So at this particular moment in the experience of mankind there is unexampled call both from the nation and from the world for those who have minds that insistently inquire as to the values in situations as they really are, and show ability to find further remedies. This means that opportunity is not just knocking at the door —it is calling loudly.

It has become the fashion to say that no other period of history has presented so many human problems demanding attention. In part this is because we have come to feel the effect of these situations through unpleasant personal experience. But these great questions were with us in the last decade, and the need for their solution was just as marked as at this moment. When disaster impends it is easy to obtain a hearing on the factors involved. When there is seeming prosperity we listen less readily to discussion of what we do not desire to see.

The basic principles of economics and government that determine action and direction of movement are the same in periods of prosperity and of depression. The mind that carries its inquiry below the superficial features has the only real picture of what is taking place. It is such a type of inquiry or vision that is needed. It does not matter whether its work is done under the stress of emergency or in periods of apparent tranquillity but of actual danger.

No one who faces the major problems of agriculture, mechanical or power industries, finance, general economic trends, international relations, or even of so-called exact science, deceives himself into thinking that all the questions have been solved. In every science, profession, or trade, the number of critical problems for which answers are urgently needed is very great. It is not possible to conduct any kind of business or professional activity without meeting them at almost every step.

I have referred to these questions in terms of inquiry rather than as research, though the attitude of mind in the two is the same. It is within the reach of every intelligent worker to make inquiry as to what things need answer, and at least to look down the path which one must follow if solution is to be found. The contribution by honest inquiry touching every aspect of these activities through practical and theoretical examination may be very large. The possibility that such collective knowledge may determine governmental policy is also important.

In this connection it is desirable for us to keep in mind that unless government over the world is to pass into the hands of the few, its success will depend upon ability to develop widely among men this habit of inquiry and honest, independent thinking at a level higher than that thus far attained.

If the world were unchanging in its physical and life conditions, and man were not driven forward by the urge of his inquisitive, constructive faculties to new levels of social, economic, and governmental organization, it might be possible to set up a program which would place less responsibility on the individual. In the changing world as it exists, our hope lies in continuous alertness, and in exercise on the part of all groups and individuals of powers deriving normally from the peculiar qualities with which mankind has been endowed. To avoid such responsibility is to invite that type of evolution advanced by the brutal laws of survival of the fittest, rather than by principles resting upon intelligent, constructive cooperation and brotherly love.

What has been said regarding society as a whole concerns also the individual, including each of us present here today. If the world program is as it has been pictured, its advance is ultimately dependent upon the thinking and action of individuals singly as well as collectively. The tendency to shift responsibility for initiative is large. In reality the value of initiative is one of the most important factors involved in the foundations of government. In this struggle for the highest type of individual liberty there are no exemptions or exceptions. The penalty for failure is not punishment as ordinarily understood, but in simple terms it involves immersion in the sea of oblivion.

The advantages derived by the individual from exercise of honest and effective inquiry as a habit of life are greater than is commonly assumed. They comprise on one hand the fundamental values

that concern the scientific or philosophic or religious conception of our relations to the great movement of evolution or creation with which each individual may be connected. In another direction they have relation to effectiveness and enjoyment of life that can be secured only in part by other kinds of approach.

I do not believe that evils arising through man's god-like qualities will, as a poet has suggested, "drive him on," to be the "wreck of his own will, the scorn of earth, the outcast, the abandoned, the alone." But I am of the opinion that if our possessions of ability and creative power are not guarded carefully we may meet disaster. Nothing less than embedding the idea of responsibility for these qualities in the mind of every individual will suffice.—This means of course you and me.—With this accomplished the world may go forward on a career of creative activity without fear.

To have even an infinitesimal part in a great movement such as the longer history of the world shows us, and to keep the touch with this advance which each individual should have, gives a dignity to life scarcely possible by any other means. Without knowledge of the past and belief in the future, life would indeed represent a hopeless existence. To eat, drink and enjoy the pleasures of the moment might under such circumstances well take a place of high importance. But, today we no longer live isolated from the past out of which man has been created, and to which we owe our existence, and in large measure our possibilities for the future. Each individual has, or may have, a part in this scheme of things that arises from a remote past, and reaches into a future that we see but dimly.

Though we are by nature endowed with qualities that lead us to inquire, investigate, and build upon new knowledge, our educational program unfortunately tends only too often to develop discipline at the expense of initiative, and imitation may overshadow inquiry and constructive ability. Psychologists speak frankly regarding the small percentage of use for aspects of the mind that should lead toward the building or creative type of effort.

But, more and more, education comes to recognize the need for development of those powers that help us to see, to find, to organize, or to create where no material of the type we need seems available. Out of these activities arises much, even in the smaller things of life, that leads to individual accomplishment, and to that attainment which is in considerable measure the wine or stimulus of life. As the world panorama changes and old things give way to new, the lure

of opportunity leads the inquirer on to further achievements and to larger interests.

Relation of the habit of inquiry to enjoyment of life is a factor of high importance. Today we look upon a degree of appreciation and enjoyment as not only permissible, but as constituting a necessity in living. Many basic pleasures of the senses begin to pall early in the span of years. Those forms of appreciation linked with imaginative conceptions linger, or show increased development with later life. Music, color, artistic combinations, with the higher values of truth, remain. The significance of money, control of organization and even of power, may fade in middle life. The joys of an inquiring mind that reaches out into the endless vistas of space, time, beauty, and reverence, continue to increase. Alike for poor and rich, for great and those of modest rank, they give that which time does not strike down, and which change only intensifies.

Out of the developing individual experience there tends to grow an attitude toward life which gives perspective instead of formless space and order in the place of aimless movement.

Some years ago, one whose name I do not know published a series of stanzas of which one voiced confidence in the ultimate values and outlook of the universe. It was presented in terms of our attitude toward fading splendor of the autumn woods. In a manner it expressed the longer vision of those penetrating minds that see in what might appear to be waning glories of humanity only a stimulus to further effort—an effort in which the elements looked upon as destructive may become a saving power.

The theme of these verses concerned destiny; with spring, summer and autumn contrasted. The first touched the influence upon us of that miracle of miracles, the opening of spring. As paraphrased it reads:

> Who walking in the spring may see
> Fresh green upon the poplar tree,
> And smiles with hope as he goes by,
> Begins to see his destiny.

The last lines, relating to autumn read:

> He who can see the glory fade
> From noble works that God has made
> And keep faith fresh in his soul's eye
> Is master of his destiny.

Those who see most clearly the greater story of mankind, with its record of progress from age to age, and know also the inherent power of inquiring, constructive minds to build out of and upon the past, can best appreciate the significance of this statement.—An educational experience has given knowledge of your abilities, and has tested your power in their use. You know also the story of that struggle for truth and spiritual liberty carried through millenniums up to this day of June in 1934, and—to each of you may I say—I am sure that with this vision of life, faith will be kept fresh in your soul's eye, and that you will be master of your destiny.

ULTIMATE VALUES OF SCIENCE

In the course of preparation of the President's Report for 1934, Dr. Merriam devoted some time to study of a section in the report concerning "Ultimate Values of Research." While considering use of this material, the idea was elaborated for an address under the title "Does Science make the World Better, or Only Richer?" delivered before the Commonwealth Club of San Francisco, a great group of constructive students of human problems. Although the material is to be used later in another way, it has seemed desirable to make record of this address in the form in which it was given, and this is done to advantage through the Supplementary Series of the Carnegie Institution of Washington.—Editor.

At this time of searching for ways in which our social and economic structure can be strengthened, it is necessary that careful examination be made of every activity and interest in life. Scrutiny may not be limited to economics and government. It should cover all types of human values. As an administrator concerned with research, it has been a part of my responsibility to accept this challenge, and to study the influence of science, as it concerns both technical advance and effect upon thought.

There has been much defense of science and some attack upon it. Mostly this has concerned material aspects of the problem and questions relating to employment. I am neither attacking nor defending, only searching for light. To one who believes that man does not live by bread alone the subject must be considered partly from such a point of view.

By reason of the fact that causes of unemployment are under vigorous discussion, the relations of science to engineering and employment have become a subject of controversy. Question is raised whether research increases importance of the machine to such extent as to reduce opportunity for the individual. Although not avoiding this particular subject, I realize that even if unemployment were not known a very critical group of problems relating to science would exist. I am concerned mainly with a broader question involving inquiry whether, by reason of science or research,

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the world has been made a better place in which to live, or life has become more worth while.

Examination of present-day appraised values of property would, I assume, bring the universal answer that contributions of science have made us richer. Even in the matter of employment, research may be given partial credit for such advance as is due to development of electric energy, telephone and telegraph communication, and a vast number of other things now accepted as practical, which have notably increased the total value of payrolls. It is true that there are critical stages in which some individuals may come into new and better types of employment, while others, with less desire for advancement, remain idle. But, on the whole, these new activities have absorbed the efforts of a large percentage of the population.

The influence of science upon possibilities for betterment of conditions in the world may be considered as affecting; *first*, our use of resources in nature; *second*, the range and value of materials and knowledge resulting from human effort; *third*, the extent to which our capacity to understand and to accomplish has been bettered; and *fourth*, the possibilities of influence upon our desires or interests or attitudes of mind.

Better Use of Natural Resources

There can be no doubt that science has increased greatly the number of natural elements or resources for which we find important use. The streets of our cities, where formerly there sparkled only a few lights without the strongly-marked modern element of color, are brilliant ways lighted by neon. This is a new contribution serving a commercial purpose. We are not discussing the ultimate value, merely the fact that it is used.

Chemistry and physics have given us an almost infinite number of products coming out of resources heretofore neglected. Such would be the dyes and medical products derived from petroleum. We have also those developments of science which make possible the discovery of enormous quantities of oil by so-called geophysical methods. Again we have new means for refinement of ores, and other products, previously not considered valuable.

In the inorganic or non-living resources, science has increased the drafts upon nature, but it has also given us better use of products. Science has yet before it the task of manufacture or synthesis of

mineral products. This may be necessary to replace dwindling natural stocks. In such activities physics and chemistry of the future will be involved.

In natural resources of the living type, upon which we depend for food and clothing, science has developed to very great extent available materials derived from plants and from animals. We now make many plants grow where one grew before. We develop from original wild plants new types with new qualities, as was done long ago by early man in the case of grains and fruits. One is justified in stating that science has made these living natural resources more useful and more abundant, and through the advance has contributed greatly toward making the world a better place in which to live. We have still a vast distance to go in learning to control the living world, but the way has been marked out, and mankind may be expected to follow it.

Accumulated Products of Constructive Activity

Organization of society has made it possible to hand down, from generation to generation, knowledge regarding location of natural materials, and to protect structures or organizations, such as great cathedrals or great cities, which require generations for their development. Most of all, science has made possible the recording and continuing development of a vast body of knowledge which no individual and no one generation could produce alone. Present-day science represents the irregularly stimulated, but practically continuous, effort of mankind from the stone age to the present, giving us organized knowledge covering past experience.

In these advances science has contributed through rapidly increasing additions to those fields which represent the physical and chemical basis of engineering in all its forms, through modern development of biological science as represented in agriculture, through better understanding of the soil and the weather. In the study of man, we have come to know something of our structure and functioning, and research has contributed the largest part of medicine.

Science has given us also an almost unbelievable view into the world around us, as seen by use of microscope, telescope, spectroscope, and the penetration of past time through vision of the geologist. The newly recognized subject known as the history of science

is one of the most illuminating types of effort, showing how civilization has developed on the basis of science, and how science has been made possible by organized society.

We have only to think what would happen to the world if all available knowledge were suspended for a generation, to realize what it would mean to begin over again with development of an alphabet, a numerical system, mathematics, physics, chemistry, and all the infinite applications of these subjects.

Increase of Capacity for Constructive Work

We find few subjects upon which there is more vigorous scientific discussion than that concerning evolution of the human type with reference to physical and intellectual capacity. Those of us concerned with the history of man in the geological sense view with interest the many stages of advance represented in a time dating back some hundreds of thousands of years. Through the ages, types of human beings have changed, and the brain seems to have varied also. At a rate comparable with these modifications we see evidence of man's gradually developing intellectual activity.

Organization of human society to such a degree as to guarantee uninterrupted protection of knowledge and its records opened the way for a more rapid advance of activity in the sense of art and science. The results subsequent to that stage do not represent wholly the capacity of individuals. They reflect in large part the capacity of the race. We are now at a stage in which society shows marvelous organization, involving widely separated groups of specialists working together, whether consciously or without knowing it.

We know that the capacity for accomplishment of society has increased. Whether the abilities of individual men will change in the future at a rate corresponding to that of past geological ages depends perhaps upon the development of what is described in these days as the science of eugenics, concerning better living and being better born. There are some who believe that the selection of physical human stocks may increase greatly the intellectual capacity of the race. There are others who hold that the influence of better environment, as affecting health, physical and mental, may itself be a factor of great importance.

The contribution of science toward influencing human capacity,

physical and intellectual, is not easy to define. There is no doubt regarding increase in length of life, and of added values in experience, made possible under controlled conditions due in large part to modern preventive medicine. That science through knowledge of heredity and influence of environment can better the situation of mankind in the future seems clear. What is accomplished will depend upon increase of knowledge, and on unselfish wisdom in its application. It is unbelievable that man should fail to apply for himself the principles used so fully for all else in the world. The study of mental condition and mental health will be one of the most important fields for research of the future.

Change in Attitude of Mind

The effect which increased knowledge, or new conditions produced, can exert upon our attitude of mind or point of view may conceivably be more important than any other influence arising from advance of science. We might be rich in natural materials and in the accumulated results of human toil, or even increase our capacity for intellectual activity, and yet the utilization of it all could lead to degradation or even to self-destruction. In last analysis, whether the world is better or merely richer depends largely upon the manner of use of what we have, and upon our desires, which tend to control our ideals.

The influence of science upon our use of natural resources, upon development of accumulated values in civilization, and upon the bettering of our capacity for activity will always be of great significance. But the ultimate value of these factors depends largely upon the effect which they may have on our attitude both toward the world in which we live and toward ourselves. There may be enjoyment and contentment and progress with small resources. There may be wickedness, and bitterness, and infinite discontent with riches and great capacity. We may abolish poverty in the material sense, and yet have poverty of mind and soul. We may free man in some measure from the drudgery of manual work, and yet leave him enchained as to spirit.

There is reason to believe that science may picture or define better attitudes of mind by teaching us to face realities and facts,—which represents the only means by which science can act,—or by teaching us to use truth, and to avoid deception of others and of ourselves.

Science has reason for concerning itself with that vision of things which may influence life by giving at the same time confidence in realities and in the significance of far-reaching conditions or laws, whether in nature or in human conduct and belief.

The influence of science upon our point of view and ideals may, by some, be thought negligible, since the attitude involved will be assumed to depend upon spiritual values, while science is looked upon as concerned only with cold facts and logic. It is, however, important to realize that by definition science represents the search for truth, whether it relate to the elements of physics, chemistry, history, or human conduct. The use of reason is only a logical extension of truth. Facing the facts by the method of science is to strip away untruth, dishonesty, self-deception. This may be by changing alchemy to chemistry, astrology to astronomy, the rabbit's foot type of healing to scientific medicine, wishful thinking to factual economics, or self-centered beliefs to honest, constructive religion.

It is also true that a broadening view of the world of things and of people expressed through science, as in astronomy, earth history, biology, or the story of life through the ages, gives a vastly increased appreciation of law, or unity, and of the interrelation of elements in the world. Such a view includes all history and our relation to it. It gives a new vision of man's place in the world and in life. It presents a new outlook over the universe, with a better opportunity for appreciation of life and a new attitude toward its problems.

Seen in this light science should aid in the forming of basic beliefs and philosophy, and even religion may use it as material with which to build. Science may be looked upon as giving reasons why every man should have a philosophy and admit it, and at least an appreciation of what religion may signify.

Scientific Point of View in Relation to the So-Called Human View

In considering the relation of science to those fields of thought which are generally deemed most clearly to express human interests, it is desirable to suggest that the difference between these points of view or attitudes of mind is not necessarily as great as is sometimes believed. Science finds need for common ground with

philosophy, art, and religion in development of a clearer, broader, and deeper view of the world of things and of people about us.

As seen by science the universe is a vaster and more orderly place in which to live than was recognized in earlier interpretation of scientific vision. But in the most fundamental aspects of his investigations the scientist sees more fully than at any previous stage that he does not really fathom nature in essence, or power, or ultimate meaning. With the advances made by modern science the so-called material universe may appear less clearly material, or at least one should say that it is still beyond our full understanding. And for the reason that science alone is not finality we need a better relation to other points of view. The interests of science, art, philosophy, and religion must be joined if their human value is to be most fully attained. Each may stand alone as an abstract or non-human value, but when human interests are touched they must come into intimate, mutually supporting relation.

In the kind of touch with life here considered science makes philosophy, art, and religion appear more evidently desirable. It aids in making clear that they represent essential phases of human thought.

Looking in the direction of human values, science finds something approaching common ground for discussion with morals in that strange mixture discovered in the physical and psychological features at the foundation of criminal tendencies and crime. Such are conditions of brain and of pathological states that lead to abnormal living. On the other hand, science comes to recognize as that which it may not yet weigh or measure much in human life commonly accepted for what it has been assumed to be.

In still another direction science may find such doctrines as those in the Sermon on the Mount, or the principle of brotherly love, sound according to ideas which govern in scientific reasoning.

So we may come to expression of belief that even more important than those values which aid to bring riches and abolish poverty is the fact that science contributes toward betterment of life by placing before us the desirability of facing the realities, or the facts, and of taking the broader and longer view with reference to everything in life. Giving increased significance to truth, and depending more fully upon it, means not only a bettered and more nearly

stable and safer world, but one in which the possibility of forward building or of accomplishment is enormously enhanced.

Science and Opportunity of the Individual

Considered for a moment from the point of view of the individual instead of the race, bettered conditions of living are defined by the degree of enjoyment or appreciation of life as it is lived, and question may be raised whether directly or indirectly science enhances values in this sense. What is comprised in joy of living should represent a considerable part of our experience.

One may look upon the elements of an individual life as made up; first, of maintenance, involving food, clothing, and shelter; second, of opportunity and materials for work and personal achievement; and, third, of the possibilities for appreciation in the intellectual, the emotional, and the spiritual sense. There can be no doubt that the contribution of science increases the opportunity and the materials for progress, or for achievement, by those who wish to achieve. For those who desire to see a static or unchanging world, science might be accused of representing an influence making for change, and of being for that reason a source or a cause of unemployment and therefore of unhappiness.

Whether science, or any other influence, can accent or increase the appreciation of what enters into life would be considered by some a question for discussion. And yet the view may be taken that through science the uncertainties are reduced, the assurance of progress increased, and the possibilities of achievement broadened in the kind of a world which science favors; a world more clearly dominated by truth and honesty; a world with a wider view indicating its magnitude, scope, opportunity, and dependability. To the extent that these conditions prevail, and that they may influence the life of each person, one might assume that science increases opportunity for constructive living as also the possibilities for appreciation and enjoyment.

The widely discussed problem of so-called "leisure time" will be seen to have its bearing upon many of the questions examined. Shortened hours of labor, made possible by modern developments, in which science has a part, mean freeing of energy and interest for new accomplishment. They give opportunity for clearer understanding, broader vision, and fuller appreciation of the elements

in life. But it might happen that hours freed from work by abolishing poverty would mean a loss rather than a gain. Also remember that this is not the only situation in the history of the world carrying promise of leisure time. Such a condition is to be found in the hut of the Eskimo today, and doubtless there were periods of abundant leisure in the Stone Age.—Preferably, I refer to this situation as presenting *opportunity* rather than leisure. Mere leisure may involve danger; widened opportunity should mean betterment. What is needed is improved vision and the higher ideals contributing toward better use of the time set free.

Education Transmits the Influence of Science

In the practical sense, the influence of science upon thought is exerted in many ways, but largely it comes through imprint of what would be called education. It may seem difficult to develop conditions under which the values of science can have real effect upon the point of view or the degree of enjoyment of life by the average person. To what extent may we expect scientific knowledge to bring about the conditions which have been discussed? In how far may we think of the interests of practical people in problems of citizenship as influenced by scientific knowledge?

Since the average person is not considered a philosopher, many will think of the view here expressed as impractical, and it may be looked upon as concerning only a small part of the population. But I am inclined to believe that the contributions of scientific thought have actually at this moment a very significant influence in everyday life. We see this in the unquestioned effect of scientific advance in the laboratories of great industries, as known to every one. Such is the influence of telephone, telegraph, and radio; also the clear gift of physics and chemistry in modern engineering. In another direction the practical relations between medicine and the underlying biology, chemistry, and physics are things known to every intelligent person.

In other ways, widely distributed and frequently stated facts noted in daily papers, magazines, movies, and books, bring to the average person an inescapable and ineradicable impression concerning the nature of scientific truth. Such are the discussions regarding experiments on the atom, the character of radio waves, the nature of the stars in terms of elements well known on our own

earth, the dimensions of the universe, the evidence of geology relating to vast periods of time, and concerning the strange primitive characters of early man as he is found associated with the extinct life of other ages. Science is itself a powerful educator just because it turns attention to real things, and away from substitutes. Nor can we dismiss the idea that the expressions of reality and law observed do not concern solely food and maintenance of life. They relate also to other values, which make evident to us from day to day the possibilities in a larger and more clearly law-controlled type of world, as contrasted with that smaller universe constructed by imagination on the basis of less extensive and less accurate information.

Only too often false sciences, arts, and religions have tended to make formal images out of thought and belief that once lived, so that the truth has been almost hopelessly obscured. Science should not only make us free from the bondage of superstition and mere fashions of thought, but it should help also to give us humility and reverence without the slavery incident to idolatry.

The philosopher and the poet have not infrequently given the clearest and the most accurate statement of problems pertaining to science. So, Tennyson, in lines well known to all, expressed one aspect of this problem when he wrote:

> "Let knowledge grow from more to more,
> But more of reverence in us dwell;
> That mind and soul, according well,
> May make one music as before,
> But vaster."

Conclusion

Perhaps these philosophic, scientific statements should be applied to problems of today. But I am not an expert in economics, politics, or government. However, no one should doubt that this outline was written for the purpose of stimulating thought on major questions of this age.

At no time in history has it been more important to face the realities on a factual, scientific basis, without illusions or predispositions, and without permitting selfishness or any other untoward human attitude to influence the decisions. In no period has there been greater need for judgment based upon a broad view of real

things as seen by science in the more general sense in which it is here discussed, and for interpretation of the place of the individual or that of the nation in a natural scheme of development.

This is a time to guard against narrowness of vision that may tend to eliminate history as a critical element in discussion of our national problems, or to obscure conditions existing over other regions of the earth. With a world drawn together by bonds that touch every aspect of life, from exchange of fundamental commodities to interaction of philosophical and religious beliefs, it is essential that situations be faced for what they actually are. This may concern policies governing exchange of food-stuffs, or questions relating to world coöperation in needed research on weather or health, or responsibility for government of weak nations. Definition of policies on a basis in which science and history fit themselves to economics and government is essential. The more directly we face the issues, with honest use of all knowledge to be obtained, the earlier may we expect the shadows of deep clouds to pass.

In the broad study of our country now under way, we have centered largely upon materials and modes of operation, including natural resources, the foundations of economics and finance, business activities, and governmental questions. All of these are important. Their ultimate significance will depend upon the care with which the facts are gathered, and how they are related to each other in organized and interpreted form. It will depend also upon the quality of intelligence used and on the ability to see clearly.

But the present situation is not due wholly to lack of data regarding these matters. Nor is it to be explained fully by influence of greed or bad judgment in any small group of people. In no small part it may be ascribed to our failure to be guided by that basic thinking, and those fundamental conceptions, which should control the thought of the world.

We should have new information with which to meet new situations, but present conditions are not so radically different from those of years just behind us. We need greatly the wide acceptance of an attitude of mind illustrated by the pattern of scientific thinking, with its persistent search for facts upon which to base judgment, and its broad vision over the world of things and of events. It is believed that such a point of view would help us to attain a higher level of ideals and aspirations. The influence of such a view upon

the mind of the people would help to carry us forward through realms of faith and hope to realization of a prosperity expressed in terms of mind and soul, and of life defined by the measure of what it could give us, rather than of what we might pay to see the passing show.

Wordsworth, a great interpreter of science in the human sense, wrote in his lines on science and the soul:

> "Go, demand
> Of mighty Nature, if 'twas ever meant
> That we should pry far off yet be unraised;
> That we should pore, and dwindle as we pore,
> Viewing all objects unremittingly
> In disconnection dead and spiritless;
> And still dividing, and dividing still,
> Break down all grandeur, ..."

I would like to see science do its humble part in helping to build a better world with all of its elements united, and to see it carry this work forward with that feeling of reverence which makes possible the appreciation of grandeur.—Whether we pry far off or look into the depths, I believe with Wordsworth that in the end, by reason of this effort, we should find ourselves upraised, and on a new level of intellectual and spiritual life.

SCIENCE AND HUMAN VALUES

While science is accepted universally as an outstanding feature of this age, there is wide difference of opinion as to how its materials and methods are related to human life. We range between that extreme interpretation which pictures scientific work as overshadowing and controlling all our interests and activities, and, on the other hand, a vision showing its results used in a multitude of ways, but without appreciable influence upon the principal values of life. The questions raised have so important a place in study of life today that they must be examined closely, if we are to attain full acquaintance with the forces concerned in evolution of society.

We may assume, as commonly accepted, that science represents an attitude of mind, or a mode of approach by which we discover and verify realities, organize facts in consistent groups, learn their true relation to each other, and ascertain their place in the larger scheme of knowledge. But more serious difficulty is met in attempting to state what things represent human value.

So largely is everyday living controlled by what concerns mere existence and maintenance of life that whatever relates to these conditions naturally has large place in any estimate of worth or value. But in spite of our apparent exalting of what are called immediately practical affairs, there are no human characteristics more widely recognized, or more influential, then those relating to beliefs or philosophies defining what is considered of value in directing the activities of life. Over the ages there has been continuous effort to state these basic ideals or principles. Even in cases appearing to represent complete absence of belief, the vehemence with which a creed against creeds is expressed seems often only emphasis upon another kind of value.

In the purely descriptive sense one might set up a group of major

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interests or values such as those relating, first, to *maintenance of life;* second, to *freedom of opportunity* to grow or accomplish; third, concerning *liberty to believe* whatever seems reasonable; and fourth, relating to *opportunity for appreciation* or enjoyment of what commends itself. In life of this particular moment, one notes that attention of the people of the country is turned toward consideration of what was intended in those basic ideas upon which government rests. The ideals expressed in the Declaration of Independence voiced the desire for life, liberty, and the pursuit of happiness. The features in growth of government to which reference is made will be described commonly as rights rather than values. The intimate structure of individual lives we must recognize as including an almost infinite number of things that we value in differing degree. But it is upon the elements common to mankind that what we call rights are based.

Combining, for the moment, the views derived from terms that are merely descriptive with those based upon age-long development of human ideals, we see what is called *life*, as it is guaranteed among the rights of government, representing maintenance of being and bodily comfort. *Liberty* expresses values in freedom of thought, belief, and action. *Pursuit of happiness* may mean opportunity to grow or to construct. Or it may be seen as the possibility for enjoyment or appreciation, involving those finer aspects of life expressed in art.

With Reference to Science and the Values in Maintenance of Life

In its relation to *maintenance of life* or being and to bodily comfort, science makes some of its most important contributions, and has many of its closest connections with what we call human value. Science is not itself the active applying agent in giving a better environment, better means of subsistence, protection against the elements, and such understanding of health and disease as makes possible for us a more effective and a longer life. But it is the contribution of science made through physical and biological research, transmuted into means for securing use of natural resources, into agriculture, into engineering, into medicine, that makes living safer, and increases both bodily comfort and enjoyment.

Regarding Science and Freedom of Opportunity

Freedom of opportunity, sometimes called liberty, has held its place among things valued by mankind because it represents that range and scope of action demanded by living souls. Liberty or freedom as guaranteed through evolution of government will be considered commonly as outside the range of contribution or influence of science. That this statement is correct one would admit if it appear that the cause of liberty and opportunity owes its success wholly to force of arms. But another element of power in advancement of human interests is found in the continuing logical statement of the facts upon which this cause rests.

To some, science is limited to securing and organizing facts, and to the kind of approach in this activity which concerns exact determination as in weighing or measuring. No one should doubt that the method of science does rest upon precise determinations of the quantitative as well as those of the qualitative type, and upon materials not only discovered and measured but verified as well. But where discoveries introduce new elements, it is also a responsibility of the scientist to proceed with logical consideration of the information obtained.

In the normal development of science, instead of excluding the logical or philosophical treatment of what is observed, one should hold that true science can not exist without considering the relations between facts. In other words, there can be no science merely on the basis of measurement and without a philosophy. At the same time it is equally clear that philosophies resting merely upon logic may not only be unscientific but unsound.

From another point of view it is important to note that the idea of science as analytical relates particularly to a stage in which the world was, so to speak, being taken to pieces by research, in order to learn its composition and structure. Modern science puts the pieces back, in order to see the universe as functioning. The synthetic aspect of science represents an advanced stage, and is open mainly to great minds with broad vision, with abundantly tested facts, and with desire to know the truth as to process and function as well as structure.

Returning to consideration of the means by which science, interpreted in the broader sense, has influence touching values in freedom

and opportunity, one may mention, *first*, its bearing upon the widening of means for self-expression and occupation; *second*, the ultimate influence exerted by a well-founded scientific philosophy of change and progress in making clear many aspects of opportunity.

Concerning the *first* point, one may note that during the depression period there has been much discussion regarding the effect of science upon employment. Against those who maintain that new discoveries increase our difficulties by throwing multitudes out of work, we have the argument that jobs made possible by new discoveries more than balance the losses in other directions. In general one may assume that we experience a rapidly changing condition with widening range of opportunity, but with inadequate means for adjustment to the shifts. Of course it is invention and engineering in the broad sense that produce these changes, but advance in scientific discovery is largely the foundation upon which the new structures are built.

Of the alternatives proposed for correction of existing difficulties one would be to end research and drift into a situation with relatively few changes.

Another alternative is to accept responsibility for adjustment to advances through discovery and invention, and to plan, among other things, a program of patenting which would consider public interest to a larger extent where such interest needs protection. In some cases scientific and industrial progress will be along lines which can in part be studied in advance, so that industrial and social adaptation can be experienced with less danger than in the past.

The *second* aspect of this comment on the relation of science to opportunity concerns the influence upon life of ideas as to change, progress, and new possibilities arising from views of the world as known to science and to history. These views of the world fitted together present a continuing stream or movement in events with marked evidence of both change and progress. Seen in this perspective, human kind shows stages of development connecting a great past with tides of movement rolling up to the present.

We see also that by its own contribution human creative activity accentuates this influence looking toward change. Honest thinking requires that we recognize the unwisdom of looking forward to a stabilized condition either of the world or of society. We should expect the normal situation to be one of almost continuous adaptation to shifting situations, either in our environment or with refer-

ence to the products of civilization itself. This does not mean overturn of basic elements, but rather the adjustment to new things built upon the old.

If this philosophy of life with its expectation of continuing opportunity be correct, it is essential that the situation be met by a widening of education for all citizens regarding the conditions involved, and with reference to the importance of an attitude toward change which will help to bring about adaptation by accepting the situation as one offering increased opportunity.

The ideas involved in such a vision of changing conditions and their continuing opportunities come in part out of a philosophy of science, which recognizes in the changing world certain exceptional elements of human value inherent in this situation.

Concerning Science and Values in Belief

Among the forces potent in human history there are none more powerful than the desire to believe what commends itself to the individual mind, and to live in accordance with that belief, or philosophy, or religion. Hunger, need for economic opportunity, and the wish for power are tremendous forces, but it is not often that they develop greater problems than those arising from belief.

To assume that science has relation to such a type of value as is represented by belief looks again like reaching beyond the bounds of what we include properly in the purposes and methods of this kind of human interest. But it is not so specifically the intrinsic elements of these values that concern us as it is the way in which they are applied. Science does not often trespass upon the realm of human desires, or of reaction to beliefs. But indirectly, at least, it may furnish means by which the individual will test some of his relations to such materials.

If beliefs owe their existence solely to what is within the human mind or soul, the relation of science to these conceptions or attitudes might well be considered as of such difficulty as to make its value small. While science will undoubtedly continue, and intensify, its study of facts relating to mental and spiritual states, it is not to be assumed that it questions the naturalness, or the right of the individual to those states or conditions of belief arising from his personal attitudes.

We have, however, reached a stage at which there is recognition of man, his being, his attitudes, his thoughts, as not to be separated

wholly from the universe of things and of minds in which he lives. We have been born out of this vastness. Whether or no we come "trailing clouds of glory," we present an interesting reflection of what is about us and what has preceded us. Our attitudes of mind and even our beliefs are influenced by the conditions of life and the greater things of present and past existence as we come to know them. Scientists do not often quarrel with the idea of good and evil, furnishing so important a part of belief and of personal satisfaction. Neither would one searching for truth hesitate to consider the values represented in aspects of conduct expressed by what we sometimes call criminal action, if such action seems either intensified or weakened by change in nervous states due to injury or disease.

The scientist asks only that there be allowed for what is believed the opportunity of exposure to values coming from broad vision of what is, and has been, in a world of things and people, now seen as infinitely more complex and more wonderful than the universe as known in any previous age.

Science does not reach to the end of an infinite past, or an infinite future, or of infinite space. It does not fully understand the atom, the chromosome, inheritance, environment, the creation of the earth, the inner regions of the sun, or the intimate history of spiral nebulæ. It is distinctly limited in every direction, but it is quite aware of this, and is satisfied to built slowly outward and upward. Science does not presume to interpret personal devotions or the belief in any philosophy or religion. It does say that each of us lives in a universe that is marked by unity and continuity in space, time, and apparently also in meaning. If this is true, what the scientist finds contributes not merely to atomic physics, or Cambrian palaeontology, or endocrine physiology; it contributes also toward understanding of the world of things and of people. It may change our point of view in many ways, even to giving us more faith in the order of the world in which we live, or perhaps more hope for the future of humanity, or more charity for a suffering next-door neighbor.

With Reference to Science and Values of Appreciation

Among the multitude of values discovered in the pursuit of happiness, an infinite number are purely individual or personal, while

others are broadly represented in the interests of mankind. Happiness may concern success or achievement. It may originate through control of power, or possession of any among a vast variety of things. The ability to enjoy or appreciate may, in some, be limited to a few overshadowing purposes of life; or it may appear in ability to find high pleasure in things of everyday life representing those great conceptions developed through art and literature.

So clearly are enjoyment and appreciation expressive of personal human reaction, that in consideration of their values science appears to offer little that can be helpful. But the experience of human beings concerning what they enjoy involves the things enjoyed, and the relation to them. Perhaps, though science may neither change nor control the elements of feeling, it can illuminate the object of appreciation with understanding, and surround it with a setting that emphasizes its qualities.—But these are precisely the functions of art, which by throwing the spotlight upon particular qualities, and producing a harmonious environment, stimulates that feeling of enjoyment which, in certain aspects, registers as beauty.—Science requires both facts and a method of statement which will make truth unmistakable. Art is that superlative presentation which arouses interest and brings the reaction of personal value.

Science is not art, but it may be doubted whether it ever attains its clearest or truest value without that form of presentation or of definition. The late Dr. Michelson, outstanding among our scientific men of recent years, insisted on this view in many illuminating discussions. Nor is art science, but there should be no less emphasis placed on the idea that art is essentially a method of stating truth. Perhaps neither science nor art attains its most effective expression alone.

It may be then that in the field of appreciation or enjoyment, so far as it includes certain common aims of science and art, science can contribute in some measure toward realization of values that are among the most important discovered in life.

In Conclusion

The formulation of this statement might well appear designed to indicate an overshadowing influence of science, entering even into the sacred precincts of human feeling concerning value. In reality the purpose has been only to show the intimate relation of science

and its methods to aspects of being that have properly so high a place in human life and value.

The attitude of science gives us a sure approach to knowledge, a widened and deepened field of vision over space and time, and added appreciation of the meaning in it all. Science opens the past for our inspection, and reveals creative activity in operation. It leads us to those doors that open out upon the unclear vistas beyond which we call future. And it invites us to build from the elements already revealed a faith that should not be disturbed by tides of years, nor by doubt concerning regions not yet fully known.

As I see the situation, the science, philosophy, art, and religion of the future should be built in such manner that each may contribute its part to a structure that will give a safer and more pleasant abode than any that man has thus far designed.

One of the greatest advances of all time was that expressed, ages ago, in the view that there is in the universe one power in many forms, or, in terms of religion, one God instead of many warring deities. It may be in order for mankind to make this discovery anew, or from time to time, when unity in views of the world and in belief seems threatened by erection of too many temples to deities of varying and perhaps inconsistent missions, in a world that, so far as nature is concerned, has operated as one system since time's beginning.

APPLICATION OF SCIENCE IN HUMAN AFFAIRS

In the voluminous literature relating to impact of science on human life there has been a tendency to stress the effects of technological development. This is to be expected since these advances result frequently in industrial change leading to wide social readjustment. It is, moreover, true that use of abundant natural resources and rapid technological progress have given implements, apparatus, and processes which have occupied time and attention of the people to such an extent that their activities, and to some extent their thought, have been turned into new paths.

It is, however, important to bear in mind that the problems of human affairs as represented especially in social evolution are not comprised wholly in study of materials, or mechanisms, or modes of operation, or organizations made possible by scientific discovery. These new things make great changes in our environment, as also in our activities, but they may not greatly affect life as expressed in guiding aspirations, and ideals. Therefore, we may not conclude this American Institute series on "Social Implications of Science" without careful consideration of the influences, direct or indirect, which science exerts upon the basic values of human life and their general relation to interests and ideals as seen in human affairs.

In a paper presented before The American Institute in February 1936 I spoke on the subject of "Science and Human Values," particularly with a view to considering the extent to which scientific influences may touch the more fundamental values of life. That paper was preceded by a somewhat similar discussion entitled, "Ultimate Values of Science." It is my desire now to stress certain aspects of the question of science in relation to human values, with the idea of considering the extent to which such influence may have effect especially upon thought and ideals. In this discussion free use is made of quotations from the papers to which reference has been made, and others among my own studies.

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Some years ago, for purposes of discussion, I used a classification of possibilities for improvement of conditions affecting mankind. Four categories were described to show the influence of science: first, the relation of scientific activities to our use of resources in nature; second, consideration of the range and value of accumulated knowledge and materials resulting from human effort as influenced by science; third, discussion of the extent to which through the ages our capacity to understand and to accomplish has been enlarged; and, fourth, the possibility that science with other factors may have influence upon our desires or interests or attitudes of mind.

There is no doubt regarding the contribution of science toward betterment of the situation of mankind with reference to the first two points, namely, improvement of our means for securing and using natural resources, and advance in organization of knowledge and materials resulting from human effort. But inquiry concerning the extent to which our capacity to understand and to accomplish has been increased is commonly looked upon as a subject for discussion. There would probably be involved improvement in the race by one or more of several means now under study. This might take place through modification of our environmental conditions, or through selection or improvement of physical stocks such as might increase the average intellectual capacity of human beings.

The fourth possibility, concerning influence of science with allied fields upon our desires or interests or attitudes of mind, involves a great range of questions, among which must be considered the fundamental character of man and his relation to the universe. Whether the nature of man is such that his beliefs, aspirations, appreciations, and ideals can be influenced by knowledge of the world about us included in what we call science, so as to change the trend of individual or social development, presents a problem of great difficulty. There is, however, a tendency to take the view that man is not to be separated sharply from the world of things in which he lives, and that evolution of the human being is ultimately determined in considerable part by relation to the surrounding universe of which he seems to be a part. If this be true, one can properly give consideration to the effect that knowledge of the developing setting, and of our place in it, may have upon our conceptions of what is of largest worth to us, and upon our attitude toward these greater values.

In our attempt to understand the contribution of science toward interpretation of the order of stability or instability in nature, and of man's place in relation to nature, and to obtain an understanding of the meaning of science in human affairs it is desirable to have some appreciation of the relatively narrow limits of acquired knowledge. Especially is this important if we wish to estimate the possible influence of great advances of knowledge in the future.

An astonishingly large percentage of intelligent people conceive of available knowledge as comprising nearly all that may be known. It has required the shock of many recent discoveries in physics, chemistry, astronomy, and biology to make clear the fact that our acquaintance with much that is nearest to us is still distinctly inadequate; and that in this present so-called advanced period we can be assured of regions of the unknown, but not unknowable, around us so vast that realization of our ignorance makes us look only with humble pride upon past accomplishment.

Human beings seem curiously inconsistent in that, though they become stunted individually if opportunity for growth or change is not available, they attempt to deceive themselves into belief that an unchanging situation is the normal condition of nature. We calculate an average rainfall and expect it to rain just so many inches, be it 24 or 46 each year. We are shocked if it rains more or less than the estimated amount. We see the rocks distorted and torn by countless movements dating through past ages of earth history, but are surprised when a slip of a few inches disturbs the seeming present-day stability and produces an earthquake.

Yet history shows us that, along with the law which states that nothing is completely destroyed, we must recognize the idea that nothing remains indefinitely the same. The geological book—the greatest historical document of all ages—gives us as one of its truths the fact that in the known record of life, covering hundreds of millions of years, practically nothing has remained unaltered; that the rule has been not only continuous change but continuous advance. Through vast periods man has himself been subject to changes like those that have been expressed in other living types; and the habit of nature so set forth seems to indicate that with the earth in continuous state of modification we may expect life and man to show for the future a rate of growth comparable to that of past ages. We have then to face not merely the question

of new knowledge which research should secure for uses of the moment, but with this we must have understanding which will guide in the continuous movement, both incidental and evolutional, which is to be looked upon as the natural order of the universe.

It seems true that a broadening view of the world of things and of events, expressed through science in astronomy, earth history, biology, or the story of life through the ages, gives a vastly increased appreciation of law, or unity, and of the interrelation of elements in the world. Such a vision includes all history and our relation to it. It gives a new understanding of man's place in the world, presenting a new outlook over the universe, with better opportunity for appreciation of values in the greater problems of life.

The effect which increased knowledge regarding the world about us and our place in it, or new phases of appreciation of the world, might have upon attitudes of mind could conceivably be at least as important as any other factor developing from advance of science. The influence of science upon our utilization of natural resources, upon development of accumulated values produced through the work of man, and upon the bettering of our capacity for activity will always be of great significance. But the ultimate value in these relations depends largely upon the influence which they may have on our attitude with reference to the place which we have in the world and toward ourselves as responsible agents in this world. There may be progress, and contentment, and enjoyment with small resources. There may be wickedness, and bitterness, and infinite discontent with riches and great capacity. We may abolish poverty in the material sense, and yet have poverty of mind and soul. We may free man in some measure from the drudgery of manual work, and yet leave him enchained in spirit.

The influence of science upon our point of view and ideals may, by some, be thought negligible, since the attitude involved will be assumed to depend upon spiritual values, while science is looked upon as concerned only with cold facts and logic. It is, however, important to realize that by definition science represents the search for truth, whether it relate to the elements of physics, chemistry, history, or human conduct. The use of reason is only a logical extension of truth. Facing the facts by the method of science is to strip away untruth, dishonesty, self-deception. This may be by changing alchemy to chemistry, astrology to astronomy, the rab-

bit's-foot type of healing to scientific medicine, wishful thinking to factual economics, or self-centered beliefs to honest, constructive religion.

As seen today the universe is a vaster and more orderly place in which to live than was recognized in earlier interpretation of scientific vision. But in the most fundamental aspects of his investigations the scientist sees more clearly than at any previous stage that he does not fathom nature completely in essence, or power, or ultimate meaning. With the advance made by modern science the so-called material universe may appear less clearly material, or at least one should say that it is still beyond our full understanding. And for the reason that science alone is not finality we need a better relation to other points of view. The interests of science, art, philosophy, and religion must be joined if their human value is to be most fully attained. Each may stand alone as an abstract or non-human value, but when human interests are touched they must come into intimate, mutually supporting relation.

Seen in the light suggested as normal or natural, science should aid in forming basic beliefs and philosophy, and even religion may use it as material with which to build. Science may be looked upon as giving reasons why every man should have a philosophy and admit it, and at least an appreciation of what religion may signify.

Science may even find such doctrines as those in the Sermon on the Mount, or in the principle of brotherly love, or in the Golden Rule, sound according to ideas which govern in scientific reasoning.

So we may come to expression of belief that even more important than those values which aid to bring riches and abolish poverty is the fact that science contributes toward betterment of life by placing before us the desirability of facing the realities, or the facts, and of taking the broader and longer view with reference to everything in life. Giving increased significance to truth, and depending more fully upon it, means not only a bettered and more nearly stable and safer world, but one in which the possibility of forward building or of accomplishment is enormously enhanced.

Consideration of the influence of science upon human beings has thus far in this paper seemed to relate itself mainly to the individual, although the title, "Application of Science in Human Affairs," is one in a series devoted to "Social Implications of Science." This method of discussion has been used as it appeared desirable to

stress the reaction of the individual, as the most definitely impressionable unit in society upon which and through which social forces may act. Important is it also to note that in this country discussion of human affairs, or of social implications, commonly is translated into terms of government, by reason of the possibilities in our form of governmental organization resting upon the will of a people, acting in considerable part as individuals, with their variously defined ideas as to what is of special value.

While important social changes may originate from adjustment to industrial reorganization following technological advance, such modifications may have less significance than shifts in point of view concerning needed governmental changes brought about by advancing education and considered judgments having their origin in fuller appreciation of the realities of life and their wider significance. As the extreme example of this type of influence one notes that we become increasingly clear regarding the impossibility of effective democratic government excepting under control of a broadly-educated, clear-thinking people insistent on discussion in terms of real things and of laws which represent natural conditions.

Social application of principles that develop out of the kind of influence discussed here may take place in a great variety of ways—sometimes through methods that are essentially applied science, as in agriculture, or fisheries, or mining, or relating to other natural resources. Other uses arise through the enormous fields of study on health, sanitation, and many factors included in welfare that have relation to control of balance between groups in our population.

In certain kinds of application which rest basically upon scientific study relations appear which are not always recognized in the individual or separated fields of science. So, for example, the rapid development of certain aspects of what has been called conservation, especially as applied in soil conservation and allied activities, involves a synthesis of elements in nature standing in sharp contrast to the more common types of scientific work concerned largely with analysis or dissection. The kind of interrelation or unity found here we see extending itself into what we call studies on population, or to questions involving man himself as a part of the natural world, and requiring for their understanding a point of view like that developed in scientific conservation research.

Adequate understanding of the ways in which science or organ-

ized knowledge may affect human affairs will be attained only when in addition to what has been mentioned we have full understanding of approaches to this problem from many points of view which have not as yet been brought into satisfactory relation to one another. So, for example, we must have a much better understanding of psychology and psychiatry in relation to individuals and to groups than has thus far seemed possible. Such knowledge will involve great advances in biology, including many aspects of physiological research intimately connected with psychology.

Unfortunately human affairs are moved to an alarming extent by elements or forces appearing in mental states which it is difficult to explain through science. Such, for example, are malice, envy, and hate, operating in individuals or in groups so as to produce tremendously disruptive influences. And yet we may inquire whether, even in handling of these factors, application of the methods of science may not be useful in attempting to secure desirable and effective means of adjustment.

Ignorance, bad judgment, and selfishness are other obstacles which block the way of advance. Ignorance can be corrected, bad judgment depends in part upon ignorance and in part upon the tendency to act without information. Selfishness is in part natural defense of the individual, and science may show what its limits of advantage should be. But where consideration of self is put in advance of all interests of all other beings, a principle is introduced which makes adequate human organization impossible, and especially the success of democratic government.

Again, among other things, it will be necessary to have a much more extensive and more intimate knowledge of history and its meaning than has thus far been secured. Not only must we know the true sequence of events in the human story, but we must understand the effect of changing environments and of genetical influences through the ages. The man of science should go at least as far as the poet in appreciating the "weight of centuries," such as is suggested in Markham's poem on "The Man with the Hoe":

> "Bowed by the weight of centuries he leans
> Upon his hoe and gazes on the ground,
> The emptiness of ages in his face,
> And on his back the burden of the world."

We see also the significance of accumulations of complex elements which enter into the structure of a life, or a government, or the physical aspects of cities or communities, as in the older parts of Europe, such as Rome, referred to by Shelley as:

> ". . . Rome,—at once the Paradise,
> The grave, the city, and the wilderness;
> And where its wrecks like shattered mountains rise,
> And flowering weeds and fragrant copses dress
> The bones of Desolation's nakedness
>
> . . . Ages, empires, and religions there
> Lie buried in the ravage they have wrought;"

This is a time to guard against such vision as may tend to limit the value of history as a critical element in discussion of our national problems, or to obscure conditions existing over other regions of the earth. With a world drawn together by bonds that touch every aspect of life, from exchange of fundamental commodities to interaction of philosophical and religious beliefs, it is essential that situations be faced for what they actually are. This may concern policies governing exchange of foodstuffs, or questions relating to world cooperation in needed research on weather or health, or responsibility for government of weak nations. Definition of policies on a basis in which science and history fit themselves to economics and government is essential. The more directly we face the issues, with honest use of all knowledge to be obtained, the earlier may we expect the shadows of deep clouds to pass.

Attention has already been called to the effect of current misconceptions regarding the actual extent of our knowledge of the world about us compared with what might be known. Having this in mind, it is important in attempting to guide development of science along the best lines with relation to human affairs that the citizen of average intelligence come to realization that he lives in a world which we understand only in part. He should appreciate the fact that at every turn he encounters the limits of his own knowledge and of our total store, and that the steps which lead to success are in many cases of a type defined by science and research. In every kind of business or occupation he moves among those concerned with attack upon problems which are new. In some small part he is called upon to help in answering these questions. The citizen should do as much as he can to secure information on problems needing solution. In a still larger way it is desirable to understand that

there is under way a movement toward solution of economic and governmental questions, and that he may exercise his privilege of giving intelligent support to those whose special work it is to investigate these matters and to pass judgment upon them.

It is a part of the duty of the citizen to know the difference between pernicious questioning and constructive thinking; to give his best thought in the attempt to learn what things of the established order should be left alone and which should be changed. He should be insistent on stability, and yet recognize the shifting character of most things natural and human, and appreciate the value of progressive movements.

The conscientious citizen must learn to know and value contributions of the specialist or expert in scientific constructive work, and call into his service men representing fields other than his own particular province. The habit of requesting properly organized investigation must be developed and put into use in directions which show promise of leading to results of importance to the community interests. In this way influence of the scientific method in human affairs may give us greatly bettered business and government, and bring about a situation in which our attitudes of mind and even our ideals may be defined more largely in terms of facts than by personal biases inadequately buttressed by realities.

In development of influence by science upon human affairs such as I have visualized, education must play a large part through giving, even in elementary courses, a better view of knowledge and an understanding of the way in which it grows. It is a fair question whether anything would go farther toward bringing us to a satisfactory appreciation of our present situation than a course of instruction on that which we do not know, but which might by investigation become known. With this there would naturally go presentation of evidence as to methods by which constructive work could help to bring this information and to apply it.

A great responsibility for realization of the possibilities in education rests upon scientific organizations giving themselves to the problems of constructive thought. Scientific institutions should aid in making clear the function of education to train in judgment and constructive or creative activity rather than merely to encourage the amassing of facts. All scientific men should see that the contributions from their investigations are not buried more deeply than were the materials from which these results have been

derived. New ideas should be fully stated, and placed where the applying engineer may secure the data which he requires to meet human needs, and where the citizen will have opportunity to find them. We have also a duty, so to organize our work that other investigators and appliers will not only know the results, but may cooperate with us to mutual benefit.

Widely distributed and frequently stated facts noted in daily papers, magazines, movies, and books bring an inescapable impression concerning the nature of scientific truth. Such are discussions regarding the character of radio waves, the nature of the stars in terms of elements well known on our own earth, the dimensions of the universe, the evidence of geology relating to vast periods of time, and connected or related facts in human history.

Science is itself a powerful educator just because it turns attention to real things, and away from substitutes. Nor can we dismiss the idea that the expressions of reality and law considered do not relate solely to food and maintenance of life. They concern also other values, which make evident to us from day to day the possibilities of advance in thought and ideals in a world in which everything is affected by those modes of procedure, or natural laws, that we recognize as essential factors in the world about us.

It is perhaps important to note that the present difficult situation in the world is not due wholly to lack of information in any particular field of knowledge. Nor is it to be explained fully by influence of greed or bad judgment in any limited group of people. In no small part it may be ascribed to our failure to be guided generally by certain fundamental conceptions or attitudes which should be dominant in the thought of the world.

We should have new information with which to meet new problems, but present conditions are not so radically different from those of years just behind us. We need greatly the wide acceptance of an attitude of mind illustrated by the pattern of scientific thinking, with its persistent search for facts upon which to base judgment, and its broad vision over the world of things and of events. It is believed that such a situation would contribute materially in the effort to attain a higher level of appreciation of existing conditions and of understanding as to the greatest good for the future. The influence of such a view upon the mind of the people would, I feel, help to carry us forward through realms of faith and hope to realization of a prosperity expressed in terms of mind and soul, and

of life defined by the measure of what it could give us, rather than of what we might pay to see the passing show.

In Conclusion

Following the recent period of intense specialization, as well as of broad differentiation, science has tended to place special emphasis on certain aspects of relationship among its many subjcts. Astronomical research pictures to us with increasing clearness the world of things about us as an integrated universe, rather than as groups of wholly separate and unrelated features. The law of gravitation may express the idea of unity as definitely as any philosophical conclusion. In biology the theory of general evolution brings into the world of living things another principle of interrelationship and of continuity through space and time.

Much as the idea of unity has developed in science, so many present-day students take the view that it is important to consider the relations between science and other human interests represented by philosophy, art, and religion. Some have seen these subjects interlocking in such manner as to make necessary consideration of all these points of view together if one desires a correct picture of the universe or of life.

Assuming that there is adequate foundation for these views regarding interrelations in science and in knowledge broadly, it becomes possible to consider the influence of science through the whole range of human interests and activities. This would not necessarily mean reducing everything to terms of science. It would indicate only that the influence of science is felt widely through human affairs.

If the points that have been made are correct, it may be seen as desirable to make sure that the science utilized is clarified and purified, and so organized that its effect may be wholly to human advantage. The way of advance to such a stage of development as has been described is evidently, first, through the building and verifying activities of research and, second, through constructive education based upon realities and utilized in such manner as to open the way for the best possible types of application to human problems.

It is, finally, essential that science in its human relation be visualized not alone as cold facts, but as a means of obtaining a clearer vision of what is, what has been, and what may come to be, both in things called inanimate and in those possessed of vitality, including such life as that represented in human experience.

PROBLEMS RELATING TO NATURE

SIGNIFICANT FEATURES IN THE HISTORY OF LIFE ON THE PACIFIC COAST

Introduction.—There are many significant features in every phase of West Coast palaeontology, but in certain aspects the history of life in this region is as yet imperfectly known, and little of world interest has been contributed. For a considerable portion of the earlier history of the lower animals we have here only a meagre record compared with that of the Atlantic Coast. Our story of the plants is largely that of the later periods. Of the age of amphibians we have no amphibian record. Of the wonderful world history of the great reptile class we know but a limited portion of the record of two groups. In the evolution of mammals we lack entirely the long record of Eocene time. After subtraction of the factors which are poorly represented there is much remaining, and it is to the features which are here unusually well expressed that the visitor will naturally be attracted.

The History of Plants.—Our knowledge of the history of the plant kingdom in the Pacific Coast region is much less advanced than that of many groups of animals. Of the plant life from the older or Palaeozoic formations very little is known on the western border of the continent, and not until we reach the next great division, the Mesozoic, do we find material which has attracted especial interest. The oldest well-known flora is that of the Jurassic period of the Mesozoic described from Oroville in California, Thompson Creek in Oregon, and other localities. In this group are many ferns, cycads, and the strange ginkgos now almost extinct. It includes many types known also in Jurassic areas of the Old World.

The Cretaceous flora is especially well represented in the great thickness of deposits of this period in the northern end of the Sacramento Valley in California. It contains many ferns, cycads, conifers, and a few of the higher flowering plants. Ginkgos are not known, but are found in a later flora. Almost without exception the Cretaceous plants belong to species not known in the Jurassic

Nature and Science on the Pacific Coast, pp. 88–103, pls. IX–XI. San Francisco: Paul Elder and Company, May 26, 1915.

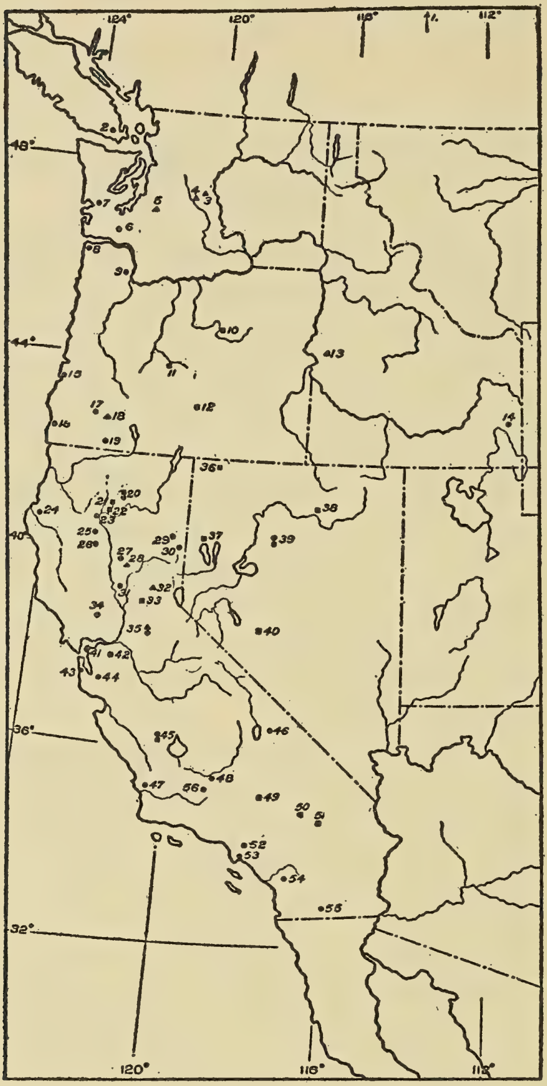

FIG. 11. Geographic situation of important localities at which fossil remains are found in the West Coast region. A square dot indicates the occurrence of vertebrates, a circular dot invertebrates, and a triangular dot plants.

1. Field, Cambrian invertebrates
2. Nanaimo, Cretaceous invertebrates
3. Swauk, Eocene plants
4. Roslyn, Eocene plants
5. Carbonado, Eocene plants
6. Vader, Eocene invertebrates
7. Montesano, Tertiary invertebrates
8. Astoria, Oligocene invertebrates
9. Pittsburg, Oligocene invertebrates
10. John Day, Tertiary mammals and plants
11. Crooked River, Oligocene mammals
12. Fossil Lake, Pleistocene mammals
13. Payette, Tertiary plants
14. Aspen Ridge, Lower Triassic invertebrates
15. Coos Bay, Miocene invertebrates

flora of this region. In a few areas of the West Coast, as at Vancouver Island, remains of Cretaceous plants accumulated in sufficient quantity to form coal beds.

In the Eocene period, following the Cretaceous, plant life was more abundantly preserved than at any other time in the history of the Pacific Coast region. It was during this time that the greater part of the West Coast coal was deposited, largely through accumulation of remains of coniferous plants. There is good reason to believe that conditions were unusually favorable during this time both for accumulation of coal and for abundant growth of plants over wide areas of low-lying land. The Eocene flora is especially well known from the coal mines of the Puget Group in western Washington, from the Swauk and Roslyn beds of eastern Washington, from the Upper and Lower Clarno beds of eastern Oregon, and from the Ione formation of the eastern border of the Sacramento Valley in California. At least two phases of this flora are known. The earlier or Cherry Creek phase of the eastern Oregon flora contains a considerable percentage of ferns and is more closely related

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16. Port Orford, Tertiary invertebrates
17. Roseburg, Tertiary invertebrates
18. Thompson Creek, Jurassic plants
19. Klamath Mountains, Cretaceous invertebrates and plants.
20. Shasta County Limestones. Triassic invertebrates and reptiles
21. Samwel Cave, Pleistocene mammals
22. Potter Creek Cave, Pleistocene mammals
23. Kennett, Devonian invertebrates
24. Eel River, Pliocene invertebrates
25. Horsetown, Cretaceous invertebrates
26. Elder Creek, Cretaceous invertebrates and plants
27. Chico, Cretaceous invertebrates
28. Oroville, Jurassic plants
29. Plumas County, Carboniferous invertebrates
30. Plumas County, Silurian and Jurassic invertebrates
31. Marysville Buttes, Eocene invertebrates
32. Chalk Bluffs, Tertiary plants
33. Hawver Cave, Pleistocene mammals
34. Knoxville, Cretaceous invertebrates
35. Ione, Tertiary plants and invertebrates
36. Virgin Valley and Thousand Creek, Tertiary mammals
37. Astor Pass, Pleistocene mammals
38. Elko, Tertiary invertebrates and mammals
39. West Humboldt Range, Triassic invertebrates and reptiles
40. Cedar Mountain, Miocene mammals
41. San Pablo Bay, Tertiary invertebrates and plants, Pleistocene mammals
42. Mount Diablo, Tertiary invertebrates and plants
43. Merced, Pleistocene and Pliocene invertebrates
44. Santa Clara, Pliocene plants
45. Coalinga, Tertiary invertebrates and mammals
46. Inyo County, Cambrian invertebrates
47. San Luis Obispo, Tertiary invertebrates
48. Kern, Miocene invertebrates
49. Ricardo, Pliocene mammals
50. Barstow, Upper Miocene mammals
51. Manix, Pleistocene mammals
52. Rancho La Brea, Pleistocene mammals
53. San Pedro, Pleistocene invertebrates
54. Santa Ana Mountains, Cretaceous and Tertiary invertebrates
55. Carrízo Creek, Tertiary invertebrates
56. Fort Tejon, Eocene invertebrates

Geologic Occurrence of Localities for West Coast Faunas and Floras of Especial Significance in a Study of the History of Life

All localities listed in this table appear on the map, Figure 11, on Page 2138. The nature of the material at each locality is indicated in the legend for this map.

Time Division		Vertebrates	Invertebrates	Plants
Eras	Periods			
Cenozoic	Pleistocene	Rancho La Brea Potter Creek Cave Samwel Cave Fossil Lake	San Pedro Merced	Rancho La Brea
	Pliocene	Thousand Creek Ricardo	Merced Purisima	Santa Clara
	Miocene	Barstow Virgin Valley Mascall	San Pablo Mount Diablo Coalinga Kern	Mascall Auriferous Gravels
	Oligocene	John Day	Astoria San Lorenzo Mount Diablo	
	Eocene		Tejon Martinez	Puget Group Clarno Ione
Mesozoic	Cretaceous		Elder Creek Chico Martinez Santa Ana	Upper Sacramento Valley
	Jurassic		Plumas County	Oroville Thompson Creek
	Triassic	Shasta Limestones West Humboldt Range	Shasta Limestones West Humboldt Range Aspen Ridge	
Palaeozoic	Permian		Shasta County	
	Carboniferous		Shasta County	
	Devonian		Kennett	
	Silurian		Plumas County	
	Ordovician			
	Cambrian		Field, B. C. Inyo	

to the Cretaceous flora than is the Upper Clarno of Bridge Creek, Oregon. In the upper flora walnut, birch, alder, oak, maple and sycamore make up a large percentage of the plants, and ferns are not known.

From strata of the Oligocene period a very few plants are known in the uppermost John Day beds of eastern Oregon.

The flora of the West Coast in Miocene time is well shown at a number of localities. In the Mascall Middle Miocene of the John Day region very abundant remains represent about eighty species. Included among these plants are the following types: willow 9 species, oak 7 species, elm, magnolia, tulip tree, sycamore, acacia, maple 8 species, sequoia 3 species, yew, scouring rushes, and a ginkgo. A flora resembling that of the Mascall beds is found in eastern Washington and in several other regions of the West. The flora of Corral Hollow in middle California is referred to the Upper Miocene. The splendid flora of the Auriferous Gravels from the Sierra foothills of middle California has been generally recognized as Miocene, though Knowlton who has most carefully studied it notes also a relationship to the Eocene. Recent work has shown the presence of an Eocene marine fauna in beds thought by many to represent the same period as formations containing the Auriferous Gravel plants.

The plants of the last two periods preceding the present, that is the Pliocene and the Pleistocene, are relatively little known, though scanty materials have been obtained from formations of both periods.

History of Invertebrate Faunas.—The unusually thick series of sediments in the Pacific Coast region presents an exceptional opportunity for the study of life zones of invertebrates. The marine faunas of a number of the periods are at least as well represented here as in any part of the world, and some of the faunas are of unusual importance. In the western region the faunas of the Silurian and Devonian are not relatively significant. Jurassic faunas are known, but are of relatively small importance. The Carboniferous and Permian are represented by abundant remains at a number of localities. The Cambrian, Triassic, Cretaceous, Eocene, Oligocene, Miocene, Pliocene, and Pleistocene are all known by faunas of unusual interest which may well attract the attention of the palaeontologist.

Cambrian faunas are found at a number of localities in the western region, among those of importance being the occurrence of Lower Cambrian in Inyo County, California, and the extraordinary Cambrian faunal representation of southern British Columbia. The occurrence at Field, in British Columbia, is among the most im-

portant of the Cambrian localities of the world. The wonderful preservation of the specimens makes possible unusually satisfactory studies on this fauna. The slab shown in Plate IX illustrates the nature of the material.

Silurian rocks are known in Plumas County, California. A Devonian fauna has been obtained from limestones exposed along the upper Sacramento River at Kennett. Carboniferous exposures of importance appear in Shasta County, California, where great thicknesses of shales and limestones contain in places an abundant fauna.

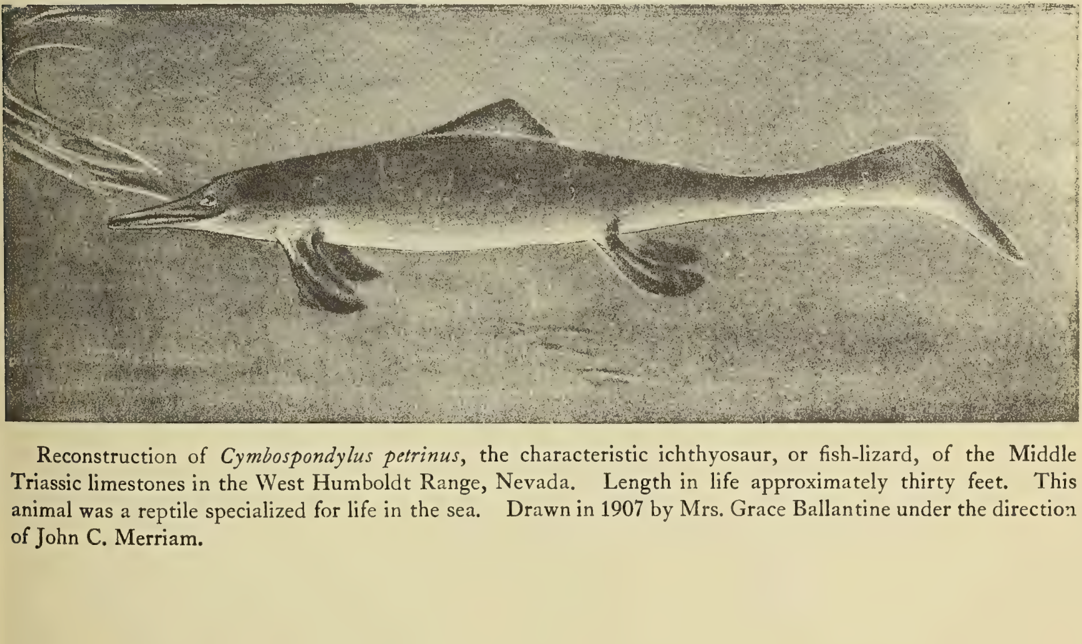
Of the whole Pacific Coast section there is no division in which the invertebrate life is of greater interest, or presents a greater variety of forms than the Triassic of Idaho, Nevada, and California. Through the work of Professor James Perrin Smith these faunas have been exhaustively investigated, and a part of the result of this work has already appeared in the publications of the United States Geological Survey. By far the most interesting phase of the Triassic life represented in these rocks is found in the nautilus-like molluscs of the ammonoid group, which are known by a great number of specimens representing many genera and species, and showing a remarkable state of preservation. In a study of the material available important results have been obtained which bear on the evolution of the cephalopods, and on the whole biological question of mode of evolution. In a number of cases these faunas exhibit close relationship with those of the Triassic of other portions of the world, and make possible important studies on the geographic distribution of animals, and on climatic changes during Triassic time. Extensive materials representing the West American Triassic invertebrates are deposited in the palaeontologic collections of Stanford University.

The rocks of the Cretaceous period are of great geographic extent and of unusual thickness. At Elder Creek in the northern portion of the Sacramento Valley, California, a measured section has been studied which approximates 30,000 feet in thickness. Three important faunal zones, the lower or Knoxville, the middle or Horsetown, and the upper or Chico, have been recognized. Abundant material representing all of these zones has been described by W. M. Gabb, by Dr. T. W. Stanton, and by F. M. Anderson. Good collections are available at Stanford University and at the University of California. The Knoxville division is by many considered

PLATE IX

Cambrian fossils from near Mount Wapta, British Columbia. There were fourteen species of trilobites and other crustaceans on the slab from a portion of which the photograph was taken. Photographed from a specimen in the United States National Museum, through courtesy of Charles D. Walcott, Secretary of the Smithsonian Institution.

PLATE X



Reconstruction of *Cymbospondylus petrinus*, the characteristic ichthyosaur, or fish-lizard, of the Middle Triassic limestones in the West Humboldt Range, Nevada. Length in life approximately thirty feet. This animal was a reptile specialized for life in the sea. Drawn in 1907 by Mrs. Grace Ballantine under the direction of John C. Merriam.

One of the University of California pits at Rancho La Brea. The numerous bones in view had not been removed from their original positions when this photograph was taken. This picture shows skulls of four sabre-tooth tigers, four large wolves, parts of the skeletons of four ground-sloths, skulls of the extinct horse and bison, and limb bones of the camel and mastodon. Photographed by John C. Merriam.

to represent the Jurassic rather than the Cretaceous. Excellent material from Cretaceous faunas is also known at many other localities in the West, as in the Klamath Mountains on the border line between Oregon and California, the Blue Mountains of eastern Oregon, at Martinez and Mount Diablo near San Francisco, and in the Santa Ana Mountains in southern California.

The marine Eocene of the Pacific Coast has one of the best represented and best known of the later faunas. At least two divisions are recognized, the lower or Martinez and the upper or Tejon, in both of which a large number of species are reported. The Martinez fauna is found in the southern portion of California, and possibly as far north as Washington. The generally recognized Tejon fauna ranges the whole length of the Pacific Coast region and serves as one of the characteristic bases for reference in stratigraphy. The Martinez fauna is well known at Mount Diablo near San Francisco. The typical locality of the Tejon is at the southern end of the San Joaquin Valley in California.

Oligocene faunas are found in Oregon and Washington, and have more recently been described from middle California.

In the Miocene an unusual wealth of invertebrate material appears in Oregon, Washington, and California. Especially in western Washington and southern California there are enormous thicknesses of beds referred to this period. At least three distinct divisions of the Miocene can be made on the basis of the faunas, and this number will doubtless be greatly increased by further study. In the immediate vicinity of San Francisco Bay excellent sections of the Miocene can be studied, but the thickest sections are represented in the southern portion of the state. In the vicinity of Coalinga good exposures of the Miocene may be seen with the Eocene and Pliocene.

Important Pliocene occurrences are those in the Merced series near San Francisco, where a splendid section of approximately 5000 feet is exposed. Good faunas are seen again at Purisima south of the Merced region, and in the Etchegoin formation near Coalinga, on the western side of the Great Valley of California.

In Pleistocene time the sea had retreated to the outermost border of the continent, but deposits of great thickness were laid down at some localities. The fauna is abundantly represented in many sections. The best known Pleistocene of the West Coast is that of

San Pedro in southern California. The fauna of this locality has been admirably described in a memoir by Dr. Ralph Arnold. According to this description the lower portion of the San Pedro Pleistocene represents a cold-water stage, while the upper San Pedro was laid down under conditions of somewhat higher temperature. In addition to the abundant invertebrate fauna of the upper San Pedro, there have recently been found in these beds a number of vertebrate remains, which contribute important information bearing on the general problem of time correlation among the Cenozoic deposits of the western region.

History of the Vertebrates.—The relatively large area covered by a thick mantle of strata deposited in a sea in the region west of the Sierra-Cascade Range has given large opportunity for the preservation of marine invertebrates, and the probabilities of preservation of vertebrates, excepting fishes and marine forms of the higher groups, are relatively small.

In the Great Basin Province no marine invertebrates are found in rocks of later date than the Jurassic period, and following this time fresh-water and land-laid deposits presented large chance of entombment of the higher types of vertebrates. For these reasons the history of the Pacific Province is known largely in terms of the stages of development of the lower animals, and a considerable portion of the Great Basin history is interpreted in terms of the succession of vertebrates.

Fishes and Amphibians.—Dr. David Starr Jordan has assembled all available information on the fossil fishes of California in two papers in the University of California Publications in Geology. The earliest described forms are rare cestraciont sharks from the Triassic of California and Nevada. Rare remains of sharks, and scales of the more modern teleost or bony fishes, occur in the Cretaceous. A few imperfect fishes have been obtained in the fresh-water Eocene of the John Day region of Oregon, and at Elko, Nevada. In the marine Eocene of the Pacific Province scattered teeth of sharks appear with fragmentary material of the higher fishes. From the Oligocene scattered remains are known, but no satisfactory collection is available. The most important fish fauna of the western region is known from the marine Miocene occurring along a large part of the west coast. As yet no satisfactory collection of this Miocene fauna has been brought together. The Miocene fish fauna includes numerous types of sharks and skates, with forms like

the herring and mackerel. Other groups of the higher fishes are known by many scattered bones and a few fairly preserved skeletons. In the Pliocene and Pleistocene many fish bones have been obtained, but the faunas as a whole are very imperfectly known.

As yet the Amphibia are known from the western region only by the remains of a peculiar toad recently described from the asphalt deposits of Rancho La Brea.

Reptiles.—The study of the great groups of extinct reptiles, constituting so important a portion of the palaeontologic story of the earth, has been limited in the western region to the history of certain marine reptiles of the Triassic period, representing the first of the three divisions of the age of reptiles.

In the Lower Triassic, vertebrates are known only by remains of primitive fishes. Middle Triassic beds are exposed both in Nevada and in northern California, but vertebrate remains are described only from the limestones of western Nevada. In the West Humboldt Range near Lovelocks, Nevada, marvelously preserved skeletons of Middle Triassic ichthyosaurs or fish-lizards have been found, associated with rare remains of another marine reptile group as yet only imperfectly known. Several ichthyosaur specimens from this region are now on exhibition at the University of California. The material is sufficiently complete to permit a tentative reconstruction shown in Plate X.

In the Upper Triassic limestones, reptilian remains are also well represented, but are known only from the exposures in northern California. Bones have been found representing the ichthyosaurs and another marine group, the thalattosaurs, peculiar to California. While numerous fragments have been obtained from these deposits, the skeletons are nearly all imperfect and do not show the wonderful preservation of the Middle Triassic specimens from Nevada.

The history of the ichthyosaurs represented in the Middle and Upper Triassic of the western region furnishes one of the most interesting studies of evolution thus far known in the story of this group. The Middle Triassic forms are much more primitive in every respect than those of the Jurassic, and show less advanced specialization of the limbs, tail, eyes, and teeth for life on the high seas. The Upper Triassic types are also relatively primitive, but are intermediate between the Middle Triassic and the Jurassic stages of evolution.

It is worthy of note that of all the multitude of kinds of marine

reptiles known to have lived elsewhere on the earth in the Jurassic and Cretaceous periods, that is, in the second and third of the three divisions of the great age of reptiles, only two or three indeterminate fragments have been found in the extensive exposures of rocks of these periods in the Pacific Coast and Great Basin regions. One specimen from the Cretaceous of California is doubtfully considered to represent a plesiosaur, a long-necked reptile very abundant in the seas of the world in Cretaceous time.

Birds.—Fossil remains of birds are among the most uncommon of the relics preserved in the rocks, and can be expected in relatively few localities. In the western region remains of bird bones have been found in several formations. Dr. L. H. Miller has summarized all of our information on the distribution and history of this group in a paper in the University of California Publications in Geology.

No birds are known from the western region in beds older than the Oligocene, from which a single bone has been obtained at Vancouver Island, British Columbia. In the Miocene several fragments are known from Nevada, from the Mohave Desert of California, and one from marine deposits at Los Angeles. In the Pliocene the materials is similarly scanty and imperfect.

The Pleistocene bird fauna of the West is exceptionally rich, exceeding in quantity of material that of all other regions of America. This fauna is known from the deposits of Fossil Lake, Oregon; Potter Creek Cave, Samwel Cave, and Hawver Cave of California; Rancho La Brea, California; and the marine Pleistocene of San Pedro. By far the most abundant remains are those obtained at Rancho La Brea. From this locality thousands of perfectly preserved specimens have been secured.

The Pleistocene fauna as described by Dr. Miller contains a large percentage of extinct species, some of which belong to genera no longer in existence. A number of the forms, as the peacock-like species, *Pavo californicus*, of Rancho La Brea have relationships with Old World types.

Probably the most interesting of all the Pleistocene birds recently described is the giant *Teratornis*, a form with a skull somewhat like that of the condor, but with a narrow beak of the eagle type. It reached gigantic size and was evidently larger than the great California condor. Remains of *Teratornis* occur in portions of the deposit at Rancho La Brea which seem to have formed relatively

late, and it is not impossible that this creature lived on into the present period, and was known to early man of this region. Condors and eagles of numerous species were represented, among them the existing California condor and a number of extinct eagles.

THE HISTORY OF MAMMALS.—Remains of extinct mammals are found in considerable abundance in the Cenozoic fresh-water and land-laid formations of the bad-lands regions in the Great Basin Province. In the Pacific Coast Province mammals have until recently been known sparingly excepting in the deposits of the latest period, the Pleistocene. The occurrences of greatest importance in the Basin Province are the John Day, Crooked River, and Fossil Lake beds of eastern Oregon; the Washtunca Pleistocene of eastern Washington; the Virgin Valley, Thousand Creek, Cedar Mountain, and Astor Pass localities of Nevada; and the Barstow, Ricardo, and Manix localities of the Mohave Desert in southeastern California. West of the Sierra-Cascade range we find a few marine mammals in the great series of marine sediments, but the most important occurrences are the asphalt deposits of Rancho La Brea, and the Pleistocene caves of northern and middle California. Several mammal faunas in association with the marine series near Coalinga, California, furnish information of unusual significance in working out the problem of age determination of the West Coast faunas and formations.

MAMMALIAN FAUNAS OF THE GREAT BASIN PROVINCE.—Within the limits of the Great Basin Province the most important series of mammalian faunas is that in the John Day region of eastern Oregon. In this area the Cenozoic section from the base upward comprises the Clarno Eocene, John Day Oligocene, Lower Miocene Columbia lava flows, Mascall Middle Miocene, Rattlesnake Pliocene, and terrace deposits of the Pleistocene. All of these formations, excepting the lavas, contain remains representing the extinct life of this region. The Eocene has an abundant flora but contains no remains of mammals. Mammal remains are found in all of the formations above the Eocene.

The mammal fauna of the John Day Oligocene includes a little more than one hundred species, of which an unusually large number of forms belong to the cat and dog groups. Of the dog family there are at least 18 species distributed among 9 genera. Of the cats there are at least 10 species, representing 4 or 5 genera referred to

the sabre-tooth group. Numerous primitive horses belong to the genus *Miohippus*. Rhinoceroses are represented by the two-horned *Diceratherium* and the hornless *Aceratherium*. The gigantic pig-like *Elotherium* is known by a number of fine specimens. Smaller pigs of the peccary type are not uncommon. The most abundant remains in all of this fauna are those belonging in several genera of the characteristic even-toed ungulates, the oreodons. Primitive camels are well known, especially in the upper portion of the series.

The fauna of the Mascall Middle Miocene is less satisfactorily known than that of the John Day, and contains a considerable variety of horses belonging in at least three genera, of which the three-toed *Merychippus* is the most common and characteristic type. The camels are much larger and more specialized forms than those of the John Day. The members of the cat and dog families are all different from those of the John Day.

The Rattlesnake Pliocene fauna is imperfectly known. It contains horses of the *Neohipparion* and *Pliohippus* groups, approaching in many respects the type of structure in modern horses. There is also a very large camel, a rhinoceros, and a large peccary.

The Pleistocene fauna of the John Day is not well known, but contains the remains of elephants of a very modern type.

On the northern border of the Nevada region are two important series of mammal beds known as the Virgin Valley and Thousand Creek formations. The former contains a fauna like that of the Middle Miocene Mascall of the John Day region. The fauna of the Thousand Creek beds is entirely different from that of the Virgin Valley formation and most closely resembles the Pliocene life of the John Day region. In the Thousand Creek fauna are a number of peculiar types not previously known in America, including certain twisted-horned antelopes which in many respects resemble some of the living African forms, and correspond approximately in the type of their horns to certain widely distributed antelopes of the late Miocene and early Pliocene of Europe and Asia.

Next to the John Day region of eastern Oregon the most important succession of mammalian faunas in the Great Basin Province is found in the Mohave Desert. At least three faunas are known in the bad-land deposits of this region.

The oldest mammal-bearing beds of the Mohave Desert are the extensive deposits of the Barstow formation near the town of Bar-

stow. This fauna represents an Upper Miocene stage not known elsewhere in the region west of the Wasatch. The Barstow fauna includes about thirty species among which the most common forms are three-toed horses of the *Merychippus* type, camels of two groups, primitive deer-antelope, four-tusked mastodons, dogs of the heavy-jawed *Aelurodon* type, and large tortoises.

A second faunal stage, evidently occurring in a second geologic formation of the Mohave Desert, appears in the splendid exposures at Ricardo on the western side of the El Paso Range, and facing the foot of the Sierras. The Ricardo fauna contains mammalian types of the same groups as those represented at Barstow, but many of the genera and nearly all of the species are different and of more specialized stages. The Ricardo fauna is most closely related to that of the Lower Pliocene. It contains several forms, especially the horses of the *Hipparion* group, which closely resemble species found in fossil beds of the Old World.

A third fauna of the Mohave is found in the Pleistocene of Manix Lake, near Manix station on the Salt Lake Railway in the eastern part of the desert. The mammalian remains at this locality are scattered and fragmentary, but represent the most satisfactory assemblage of Pleistocene forms known in the Mohave Desert area. They include two horses of the genus *Equus*, two extinct camels, a proboscidean, an antelope, and several birds. A number of fresh-water molluscs are also found here.

Faunas of Pleistocene Caves.—A number of important discoveries of rich mammal-bearing Pleistocene deposits have been made in caverns situated in the limestone regions of the mountains of northern and eastern California. The faunas obtained in these caves have contributed much to our understanding of the history of mammalian life on the Pacific Coast.

Potter Creek Cave, in Shasta County, furnished a fauna comprising more than fifty species, of which approximately one-half are extinct. Included in this fauna are the great bear *Arctotherium*, a bear of more modern type related to the black bear, a puma, a large extinct lion, an extinct wolf, and fragmentary material representing the deer, mountain goat, ground sloth, bison, camel, mastodon, elephant, extinct horse, and a goat-like animal known as *Euceratherium*. Samwel Cave, also in Shasta County, contained a fauna differing to some extent from that of Potter Creek Cave. The great bear is

absent, and there is present another peculiar goat-like animal known as *Preptoceras*.

Hawver Cave near the town of Auburn, on the overland line of the Southern Pacific Railway, was discovered by the late Dr. J. C. Hawver, through whose interest much material of scientific value has been brought to light. The collections from this locality comprise a number of extinct mammalian forms, but investigation of the fauna as a whole has not been completed.

Rancho La Brea.—The deposits of fossil skeletons in the Pleistocene asphalt beds of Rancho La Brea constitute one of the most interesting features in the history of life on the Pacific Coast. The unusual nature of the accumulation, the vast quantity of material, the marvelously perfect preservation, and the great variety of life represented all serve to mark this locality as one of the most important occurrences of remains of the life of a past period known in America. The site of the excavations is about seven miles from the middle of the city of Los Angeles and is within a stone's throw of Wilshire Boulevard, a fine automobile road between Los Angeles and Santa Monica. The locality can be reached by automobile in twenty minutes from the central part of the city.

The bones are found at Rancho La Brea in asphalt pits or chimneys which are the vents through which oil and gas have escaped from great reservoirs of oil located far below the surface. The geologic history of this region indicates that bending or breaking of the strata has permitted the oil and gas to escape. Since the first accumulation of the asphalt, there has been very frequent trapping of animals coming in contact with the sticky pools. Wherever oil is exuded at the present time we find birds, gophers, squirrels, dogs, and even cattle frequently entangled. This process has led to the accumulation of great quantities of remains of animals in times past. In many of the pits the bones are found massed and matted together in enormous numbers. Literally hundreds of thousands of specimens have been obtained from these deposits. The photograph shown on Plate XI illustrates a typical occurrence in one of the University of California excavations. The great number of specimens are shown in place, exactly as found.

The representation of ancient life at Rancho La Brea comprises numerous species, the total number amounting to considerably more than one hundred forms. These include an extinct bison, an extinct

antelope, an elephant, a mastodon, extinct species of horse and camel, a sabre-tooth tiger, a giant cat closely related to the existing lion, great numbers of extinct wolves and coyotes, a gigantic bird with characters to some extent intermediate between the eagle and condor, many condors, vultures, owls, eagles, hawks, and a great variety of other birds and mammals. There are also remains of toads, and snakes, insects, thousand-legged worms, many leaves, and twigs of large plants, and even considerable parts of tree-trunks with the attached limbs.

The bones are all as perfectly preserved as though buried within the past few years; they can be assembled in complete skeletons which may be multiplied to hundreds in the principal collections. Several of the animals represented in such abundance at Rancho La Brea were known only by rare or fragmentary material before the discovery of this deposit, so that the opportunity for study offered in the Rancho La Brea collection is unusual.

The wonderful Rancho La Brea fauna obtained from the asphalt pits comes from deposits accumulated in the Pleistocene period, which preceded the present day by many thousands of years. As oil and asphalt are constantly being exuded from the soil in this region, it is natural that in some localities deposits of the present day, and stages between the present and Pleistocene, may be associated with the older deposits of Pleistocene time.

Good specimens representing the principal animals of Rancho La Brea are to be seen at the Museum of History, Science and Art in Los Angeles, and at the University of California in Berkeley.

Prehistoric Human Remains.—Among the most interesting west-American occurrences of actual human bones which have made some claim to antiquity are the famous Calaveras skull, certain stalagmite encrusted human bones from Stone Man Cave near Potter Creek Cave in northern California, and the recently discovered human skeleton from Pit Ten at Rancho La Brea. The Calaveras skull is now generally held to have come from a cave deposit, in which it may have been entombed for many years. This widely known specimen, monographed by Professor Whitney, and ridiculed by Bret Harte in his well-known ode to a Pliocene Skull, is evidently not the skull that was placed in a mining shaft for thepurpose of perpetrating a joke on the miners. The remains in Stone Man Cave were covered with a considerable layer of stalagmite and may

be very old, but it is not possible to make certain of their age. The specimen found at Rancho La Brea was associated with a fauna which is mainly Recent. The peculiar nature of the occurrence in asphalt chimneys at Rancho La Brea makes difficult any definite determination of age from occurrence alone.

In the San Francisco Bay region human remains are abundant in great shell-mounds at Shell Mound Park in Emeryville, and at Ellis Landing near Richmond. These mounds have been partially buried by gradual up-building of the surrounding marsh, coincident with a depression of the region which carried the bases of the mounds from an original position above the sea to a situation many feet below mean tide level. The remains in these mounds are certainly very old measured in terms of years, but they are very young geologically, and belong to the present or Recent period.

SOME OBSERVATIONS ON CLOUD-BURSTS

WHILE engaged in field work in central Oregon during the summer of 1899, I was frequently warned against camping, and particularly against sleeping, in dry runs or narrow cañons, as sudden floods resulting from cloud-bursts were said to be not uncommon. I must confess, however, that during this season the descriptions of these phenomena which I heard seemed to me greatly exaggerated. During the following summer's stay in that region I learned that, although the cloud-burst may be wrongly named, the reports concerning its destructive power had not been misrepresentations.

On the afternoon of the 23rd of June, 1900, Mr. J. C. Sperry and I were working, without hats or coats, partly in the shade of a low cliff, when from a slightly clouded sky there began to fall what I might best denominate balls of water. The term *drop* would not sufficiently dignify them. One could hear them spat-spat on the ground or thump-thump on one's head like little marbles. The sun was shining brightly, and, looking straight up into the sky, the myriads of little spheres presented a truly remarkable spectacle. So noticeable was it that nearly every person in the region, who saw the storm, noticed particularly the great height in the air at which the rain could be seen. Thinking that the shower would soon pass, we kept at work for some time, but soon heavy clouds swung across the sky and rain began to fall almost in torrents. During the next hour, while slowly picking our way along the slippery back-trail, we were exposed to one of the hardest rain-storms that I have ever seen. As is usually the case in such experiences, it cleared as soon as we reached camp.

Some weeks later, we passed along the Dalles road, thirty or forty miles to the west of the point at which we had been caught in the storm, and found that on the afternoon of June 23rd this part of the country had been visited by a cloud-burst. As we entered the devastated region, evidences of the extraordinary activity of water

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were encountered at every turn. Close to the tops of hills, where water would have no chance to accumulate, the grass was plastered as close to the ground as it would have been if a steam roller had passed over it. From the mouths of all the gulches, great streams and fans of large rocks were spread out over the flats, sometimes being carried for considerable distances across perfectly level ground. In one little valley, an alfalfa field a mile long was completely destroyed and a large part of the ground covered with gravel, making it useless for agricultural purposes. The storm was here accompanied by a heavy fall of hail-stones of enormous size. Some measured specimens showed a circumference of over six inches. In a grove of junipers, through which we passed, at least half of the small branches and twigs had been snipped off by the hail. The dimensions of the hail-stones I could easily understand when I remembered the remarkable size of the raindrops seen by us at the time this storm was in progress.

In the storm of June 23rd, no lives were lost though much property was destroyed. On other occasions the results have been more disastrous. In 1884 a storm heading near Mitchell raised Bridge Creek so that it is said to have advanced down the valley as a cataract many feet in height. Half an hour after the first rush, the water had risen fifteen feet over the valley floor, and an hour later it was down at its original level. A young man, who as a boy was almost miraculously saved from the flood, stated to me that he remembered crossing the dry road as he ran away from the stream and being immediately afterward swept off his feet by the water coming behind him. From that time he knew nothing till about four hours later, when he was lying in the sage brush with his clothes torn and his hair full of sand. His deliverance he probably owes to a large dog which was with him as he ran for his life and which was standing by him when he regained consciousness. The boy and the dog lay all night in the sage brush and were found by a search party the next morning. Of four other members of the family who started with him only one escaped. His mother and two brothers, who were only a few yards behind him, were overwhelmed and carried away by the torrent.

Again in 1896, in the same valley, the stream rose twelve feet at a jump, doing considerable damage to property.

The old inhabitants think that the cloud-bursts of recent years

are caused by a change in the climate due to stripping the country of its grassy mantle by sheep. A few decades ago the region was covered by a heavy growth of bunch grass but now it is almost bare. This change, in a climate already none too moist, is certain in time to result in serious evil to the country, if it has not already begun to be felt as a modifier of climate. Whether or not there is any connection between the greater frequency of cloud-bursts in recent years and the increased tendency to dryness owing to the loss of the natural grassy covering, it is certain that some of the important requirements for such climatic conditions as usually obtain in regions frequented by cloud-bursts are being rapidly satisfied.

RECREATIONAL, ECONOMIC, AND SCIENTIFIC VALUES OF WILD LIFE

STRICTLY interpreted, the scientific, economic, and recreational values of wild life include every possible phase of usefulness of all living things which man has not brought into a stage of domestication. These values divide themselves into the contributions which wild plants and animals can make to our practical subsistence and bodily support and those which concern the use of unmodified or uncontaminated nature for the higher purposes of man expressed through recreation and appreciation.

Scientifically, the world of wild life furnishes a great laboratory for study of an almost infinite variety of problems which touch all the fundamental questions regarding the nature of life—a field into which we have as yet had only the most imperfect view. The study of man himself and the comparative examination of domesticated animals and plants will always tend to furnish the major opportunities for investigation of life phenomena, but the range of possibilities is always limited in many directions. So long as it remains desirable to continue our search for facts and interpretations of the physical or life characters of man and of the associated creatures and plants upon whom his life depends, for just so long a time will the unmodified remainder of the original life world in which we came into being serve as an asset of incalculable value. Upon the scientific understanding of this aspect of nature we may depend for much that is needed by biology and medicine to give us an understanding of what that so-called element of health really is—for which many seek vainly through undirected or misdirected recreation.

The aggregate economic values to be found in wild life are enormous. I shall not make a point of calculating what the figures may mean in any present valuation of undomesticated wild flowers or

Address before the National Conference on Outdoor Recreation, Washington, May 22, 1924. *National Conference on Outdoor Recreation*, pp. 17–21 (68th Congress, 1st Session, Senate Document No. 151. Washington: Government Printing Office, 1924); *Playground*, vol. 18, no. 4, pp. 203–204, July 1924.

forests—of feathers, furs, or meat. One of the most important questions to-day from the economic standpoint concerns the possibility of a continuing supply from the present source. Dealing with living things we need not assume that with a single harvesting the end is reached. With our wild life now making an economic contribution the great problem concerns conservation in the sense of such better utilization as will insure a continuing asset for the future. It is here that science, recognized as classified common sense, should be joined with the unclassified variety of the same thing in bringing us the facts as to what can and what can not be done to give us in perpetuity those economic assets which we may so readily eliminate completely. We should approach as nearly as conditions will permit to a full understanding of just what we possess, how we may use it to best economic advantage, and what the conditions are which must limit or control continuing possession.

We do not begin to know what great potential economic value much of our wild life may possess. The larger number of our domesticated plants and animals are derived from the native stocks in that part of the Old World where the human family has lived longest, and in which it has had the largest opportunity to form acquaintance with the life about it. We have reason to believe that a great number of the wild plants, and many wild animals, of regions only recently occupied by man may possess features of great importance to us. Scientific study as a common-sense investigation aimed to secure facts and interpret them should give us information about every phase of each type and each group of living organism, both alone and as a part of the total life community. Such a study gives us the material from which we can determine what may be useful and what is not helpful to us.

There are some who have seemed to feel that certain animals and plants were foreordained to domestication for human use, while others can never serve us. Some state that so long as we have a group of plants and animals that furnish food and clothing it is easier to continue the development of what we have than to search in nature for something which may require milleniums of development before reaching a stage of availability equivalent to that attained in those already domesticated. This would be true if every possible useful element of plant and animal life were known to be available in domesticated or cultivated species. But there is good

reason to believe that the present selection which we command has been determined in considerable measure by the accident of man's original location. Had we developed in some other portion of the world, the plants and animals now at our disposal under domestication might represent quite different groups.

If we could state definitely to-day what the scientific uses of wild life would be in the future, we might perhaps classify plants and animals into those that are useful, those which are tolerable, and those that are harmful. On the basis of such a classification we might properly initiate at once a campaign of protection for those that are useful and extermination of those that are harmful. But if there is anything that science makes more clear to us, it is that our present-day knowledge is distinctly and painfully limited in every direction. We can no more predict to-day the values to be derived from either the plant or the animal world in the next thousand years, than the average American Indian, who a thousand years or more ago daubed his implements and ornaments with asphalt, could have predicted the development from petroleum of the wonderful variety of brilliant dyes, or the great range of valued medicines, or the possibility which gasoline would offer for creation of the automobile and the airplane.

It is, therefore, of the utmost importance that as the wave of so-called civilizing influence sweeps across the world, laying in waste a large part of the great realm of our natural resources, we protect for future examination some of the marvelous wealth of the life of the world which the infinite wisdom of the Creator has prepared for us through hundreds of millions of years of evolution.

The insignificant areas of various types of plant associations which the botanist, the forester, and the ecologist desire to have set aside for future enjoyment and study, are pitifully small as compared with the enormous space in the public domain which will be brought under cultivation within the next century. It is of the utmost importance that we select from these regions areas representing every type of plant and animal life which may be set aside for preservation, protection, and for intensive scientific study—such tracts as guarantee by their size and location the possibility of continuing uncontaminated areas for at least one thousand years in the future.

Let us also bear in mind that nature without our aid has pro-

duced a vast variety of living types that now people the earth. It is to be assumed that man in his intellectual advance will not only select the types which he most needs for his own purpose, but that with advancing knowledge he will make such acquaintance with the laws of nature that the principles which have made possible the growth and evolution of life may be turned to his advantage—and used for the rapid development of new types peculiarly adapted to his growing needs. It will, however, be presumption on the part of man to assume that with his developing wisdom he has yet reached a stage at which it is wise to assume that the laws and methods of operation used by the Creator in making the living world may at once be set aside for man-made methods. Is it not better that the human hand which rests so heavily upon nature be used in some measure for protection, rather than for contamination and destruction, and that nature be left at least some small opportunity to do its continuing work, as it has been done through the ages before we came upon the scene?

The recreational values derived from contact with the living aspect of nature concerns that wide range of health-giving and life-stimulating activities ranging from the zest and joy in the game of the hunter, whether he be armed with gun, camera or butterfly net, to the aesthetic appreciation of the artist or the glorious recognition of the plan of creation by the scientist and philosopher. Such recreation never stands as an end or purpose in itself. It represents rather that enjoyment of life which is a natural and indispensable part of living. It should so far as possible be a part of everyday life and serve as an element in continuing growth or rejuvenation.

Whether consciously or not it brings with it an inevitable appreciation of the fundamental elements from which arise the larger vision of art, philosophy, and straight thinking. It always touches those deeper problems which frame the foundations of our faith, and make the only firm basis of feeling and judgment upon which dependable citizenship can rest.

No one may deny the charm of nature without life. As a poet has said, "The desert may be a place for weary souls to rest"; but the full value of nature and out-of-doors is realized only in completeness when the background of the landscape shows us a picture of the forest, the meadow, plant and animal life in all its various

forms, with the stimulus which comes through contact with living things.

It is not my purpose to discuss in detail the meaning of the beauty or stimulus that comes from contemplation or closer study of either the plant or the animal world, nor is it my intention to discuss the great range of splendid recreational opportunities. These are joys which appeal to you individually in their various aspects in different ways. It is rather my desire to emphasize in general terms the meaning of the whole setting for the development of opportunity for healthy living and high thinking.

We need now a recreational policy that will promote the bodily, mental, and spiritual health of all the people, by opening the largest opportunity for use, knowledge, and appreciation of the world about us in its most attractive forms. Let us turn to sane enjoyment and utilization of the best that nature in its vast aeons of preparation has made ready for our use. Life is worth what we derive from it—no more and no less.

There may be differences of opinion as to how the full advantages of a national recreational policy are to be developed from the generalization stage to the particular application. When the problem is complicated there are naturally many views.

From my acquaintance with scientific men and lovers of nature there seems no doubt that as William Cullen Bryant says, "To him who in the love of nature holds communion with her visible forms she speaks a various language." I am also made quite sure through the same lines, that for all of us she has the "smile and eloquence of beauty" and that even in the times of "darker musings her mild and gentle sympathy will steal away the sharpness ere we are aware."

I am quite certain that through this great conference under the guidance of the President and the committee of distinguished assistants whom he has appointed, there will be laid down such plans for action as will realize for the whole people the means for better utilization of the great heritage of life which we of this country still have in large measure remaining. And in the plans for use and protection of other living things, I am sure we shall be only supporting that higher aim of conservation and better utilization of the health and joy of life and ideals of the people, from which come the strength and the soul of the country.

DEDICATION ADDRESS, FRANKLIN K. LANE REDWOOD GROVE

The large group of citizens supporting the aims of the Save the Redwoods League recognize the redwood forests of California as one of our most valuable possessions and desire to secure for them the highest possible use. This movement has naturally directed itself toward several principal objectives covering the present and future value of the forests for a wide variety of economic, recreational and aesthetic purposes.

Initiation of the plan to save certain portions of the forest in their primeval state made necessary a kind of conservation or fullest utilization effort different from that generally characteristic of such programs in the west. No part of the area considered was the property of the Government and the region could not be set aside for community purposes merely by resolution of any legislature. From the beginning it has been necessary not only to determine what the present and future needs of the community may be, but to recognize as well that every acre of timber available is the property of individuals and of corporate interests naturally concerned with its commercial use. The study of this situation has, therefore, involved a large group of factors, and required extremely careful examination in order to find the means for fair and satisfactory adjustment.

In development of its plans the Save the Redwoods League considered it extremely important to secure the best advice of those acquainted with all the interests of the community. It was after such careful discussion of our needs that Franklin K. Lane was asked to be President. He consented and became the chief officer and an active adviser in developing the plans of the League.

It is by reason of the great service performed in the interest of this organization and of the whole country that friends of Mr. Lane planned to perpetuate the influence of his work through presenting

Address at the dedication of the Franklin K. Lane Memorial Redwood Grove, August 24, 1924. *Dedication of the Franklin K. Lane Memorial Grove*, pp. [3–5]. Berkeley: Save the Redwoods League, 1924.

to the state as a memorial one of the finest units of this rapidly developing park system.

Recognizing that no program such as has been proposed for preservation and utilization of this portion of the forest can be expected to serve indefinitely without continuing support, the League set out to secure funds needed to place this grove as nearly as possible in the state of nature, and to keep the camping area in condition to give largest opportunity for enjoyment on the part of visitors. It was the purpose to make this memorial as nearly as possible a pattern for future development of such portions of these forests as may be secured for public purposes. It was desired that this become a point of radiation for the kind of influence in this movement for highest utilization typified by the man in whose honor we are assembled.

In dedicating this grove to the memory of Franklin K. Lane and to the promise of his continuing service through such a living memorial, we are carrying into the vital personalities of these great trees some portion of the influence which he has exerted upon us. Added to the dignity and nobility with which nature endowed them, there come now to these members of the forest the honor and responsibility of carrying into coming centuries an expression of the meaning and power of an outstanding human life. We have faith both in the trees and in the generations of men following us that what is established here today will continue through time into which as yet our vision fails to reach.

Even the utmost limit of human expression does not enable us to convey a message which will attain conscious recognition by this forest; but the evidence of what the trees are now and what they have been permits us to voice to others, if not to them, a confidence that our belief in their continuing service will be amply justified. Combining beauty with majesty, they stand before us the most venerable of living things. Here they have waited for centuries, representing a race which counts its generations back through years beyond our understanding. Before our mountains were born, and in ages when the sea still strove to hold the land on which we are gathered, the ancestral forests from which our Redwoods have sprung spread across the world, clothing hills and valleys much as we find them here today. In this vast period creation was giving to these trees a strength and dignity and grace

expressed in form and feature such that when we see them now there is lighted in us the desire to mould our lives to match their standards. And so we know that the habit of their living, fixed in past aeons, will continue, and the members of this grove, standing in solemn quietness will serve that noble purpose for which they are chosen.

We can express our faith also that in the generations of mankind to follow us the objects of the ceremony today will be continued with strengthening purpose to assure the highest use in which this grove may serve, and to keep fresh the memory of the man whom we are here to honor.

The movement for saving of the Redwoods, with which the dedication of this memorial is linked, has received such support as has rarely been given to any program of this nature. The purposes involved in the plan have extended themselves from the securing and protecting of limited tracts of forest to consideration of questions which concern the continuing growth of timber for future generations. They have touched even the most fundamental consideration of little known technical and scientific problems which must be settled before fullest realization of commercial values in reforestation and in forest protection can be attained.

But with such vision as has been shown by those supporting the movement, and with the wholehearted support which has been furnished by every interest touching the work, we must realize that attainment of the objectives is only beginning. We are just now coming to understand the needs of state and nation which should be met by setting aside of forests for future recreational, scientific and aesthetic purposes; the needs of the lumberman for study of reforestation open an attractive and important field for future effort; and requirements of the community for a knowledge of ways in which the products of trees may be most useful furnish wide opportunity for application of the highest knowledge and skill.

The success of the program aimed to secure wisest use of this great asset of the country depends ultimately upon interest and support of those who recognize our responsibilities to the future as well as to the present—who see that in development of the people of which we are a part there is now, as in every other age, much that should be done today and not tomorrow—much that if

not done today shuts out forever great possibilities of further progress.

We may not forget that in a true democracy the duty of citizenship extends beyond relations between members of a community at any given time. It involves a definite accountability to the past out of which we grew for all that the Creator and our ancestry have prepared for us in materials and in the power to use them. It includes the obligations to those arising from us and building on what will be their heritage.

It is both the privilege and the duty of each generation to experience that joy which only the living of its own natural life can give. But no such pleasure is complete if based on the assumption that any generation lives for itself alone. A wide reach of opportunity for accomplishment is open to those who see that, small though their part may be, they have a place in that progressive movement of the world in which present links itself to past and future; who with an attitude of humility toward the power which moves the universe experience the joy of knowing that the heritage which they pass on is not less than what they have received.

In attempting to realize his ideals of democracy Franklin K. Lane based a vigorous and constructive life upon an understanding of the principles which experience of the past has formulated for us. He recognized the right of equal opportunity for all, both for those of the living present and those who follow us and he paved the way for betterment in the many fields of national interest which he entered. So the memorial dedicated today will honor him as a continuing living force exerted day by day and year by year upon the lives of those who come to know the message which these trees will carry.

THE RESPONSIBILITY OF FEDERAL AND STATE GOVERNMENTS FOR RECREATION

OUR present government is in a sense a fortunate compromise between two schools of thought: on one hand centralization of power or federalization, on the other hand maximum spreading of responsibility to individual or local agencies. Government of intelligent citizens will of necessity always represent an arrangement balancing that which the individual concedes to the community, in order to secure advantages of united effort, against what he considers the requirement for that freedom of action without which his individuality vanishes.

The same formulation of thought which has placed relatively large political power in the hands of distributed units, as cities and states, has moved to fix limitations on economic control. We have now a fairly clear idea that with enormously increasing bulk and complication of machinery of civilization it is unwise to centralize direction of government for more items than absolutely require such handling.

At present two widely separated stages of social machinery, namely, the Federal Government and the Municipality, are relatively strong. In many respect the State has received comparatively little attention as to its political, economic and other functions compared with the objectives and machinery of the City and the Federal Government. In no particular is this disparity greater than in consideration of recreation and recreational facilities, especially as represented through opportunities afforded by parks. A fundamental study of this question in all its aspects is needed, with assistance of experts in fields ranging from political problems to spiritual welfare in its relation to citizenship.

There are probably few aspects of normal life more distinctly personal than recreation. The value and need of such activity,

Address before the National Conference on Outdoor Recreation, Washington, January 20, 1926. *National Parks Bulletin*, vol. 7, no. 49, pp. 5–8, March 1926.

controlled as it is by a great variety of factors, is dependent upon the purely individual equation.

Recreation as understood in this discussion is not easy to define. It is probably best to consider that it represents outdoor recreation for the purpose of rest, and of both physical and spiritual exercise of the type that builds and strengthens.

Recreational possibilities are typically of local rather than general nature. Exception may occur where an unusual opportunity is offered that is of limited extent.

It is generally recognized that cities have obligation to provide appropriate spaces for outdoor exercise and refreshment of the highest type. City parks are today our most highly developed agencies of this character.

States are also developing areas offering possibility of recreation and growth. These State parks, more readily than city parks, can express that important quality of magnitude making possible solitude, which is so important a factor in rest and recreation. It is now becoming the fashion for cities to secure tracts of land in remote regions, thus reaching out to overlap one function of the state. A certain extent of overlap of this nature may be desirable. Perhaps ultimately city political organization or government will reach over to touch federal government, leaving little room for states between. Though cities seem to show more evidence of natural unity than states, I do not believe that this will be the case. Rather do I expect to see states increase the strength of their position and expand the larger recreational areas so as to meet needs of all the people, including city dwellers.

While there was wilderness to spare in this country attention was not drawn to the necessity of providing that opportunity for outdoor life and recreation which has contributed so much toward formulating our ideas of freedom in things political and spiritual. Now that population increases and the wilderness is absorbed, we naturally consider provisions for this feature of normal life.

Responsibilities of the Federal Government for contribution to meet needs of the people for outdoor recreation are assumed at present mainly through two agencies, National Parks and National Forests.

National Parks have been established thus far almost entirely from public domain. They have protected for use of the people

areas containing exceptional natural features with sufficient surrounding territory to preserve their primitive character unimpaired. The purpose of use and enjoyment in the highest recreational sense has been prominent in definition of their function. The element of magnitude, such as permits undisturbed appreciation of these wonders, has been clearly recognized in fixing wide boundaries.

National Forests were set aside by reason of their economic value. They are administered with a view to giving maximum contribution in many uses possible along with realization of intrinsic values in the forests represented. Correlated with administration of the great National Forest areas for economic purposes of many kinds, there has naturally developed the effort to make these regions useful for recreational purposes. This opportunity presents one of the most important possible means of meeting extensive recreational requirements. Such administration of National Forests will doubtless be supplemented in time by similar use of other large areas of forest lands, publicly or privately owned, which may have great recreational value if held under proper restrictions.

The recreational uses of national forest and national park reservations will naturally tend to run parallel in some respects. In the case of the forests, the areas will be kept protected first because of economic value. In the case of the parks, general recreational, educational, and æthetic uses have furnished the reason for existence.

The National Parks are commonly considered essentially designed for recreation, and this must of course be one of their major functions. At the time the first national park was created large spaces were available for purely recreation purposes elsewhere, but these were not given special protection as was the area converted into a national park. The recreational use for which these parks serve is secured under conditions particularly favorable to education and growth of mind and spirit as well as of body.

The ideal which has made a weekly day of rest hold a place in America has supported the better recreational phase of our life, not merely as a time to abstain from labor, but as one for physical and spiritual reinvigoration. We are coming to learn that life is worse than useless if it does nothing more than connect a chain of circumstances permitting its continued existence in the physical sense without mental or spiritual values.

The shorter catechism states that man's chief end is to "Glorify God and enjoy him forever." I always read it "enjoy it forever." In the state of Iowa, from which I came, we learned early that it is not the chief end of man to raise more corn to feed more hogs to make more bacon to feed more people to raise more children to plant more corn—or any other similar cycle; but that it is part of man's normal life to appreciate as well as to use what he finds about him. The multitude of colleges in Iowa is evidence that this discovery was made.

Under guidance of recent administrations, National Parks have developed steadily in the direction of educational influence through use of the unsurpassed illustrations of natural phenomena, which were the features that really brought about their creation as separate establishments under the government.

As I have given something more than forty years to study of special problems such as the parks interpret, and have lived thirty of those years among the parks, I have some confidence in saying that for many purposes their purely educational value is far beyond that of any regularly established, formal educational institutions. Among the most important features are those which concern the nature of the earth—the manner of its building—the forces which have come into play—the meaning of the almost limitless history of earth-making as it is pictured before us. David said, in viewing the works of nature, "The heavens declare the glory of God, and the firmament showeth his handiwork." This work of the Creator's hand presents itself here in such a way that all may comprehend. Here is found also much that represents the unmodified primitive life of the world, both plant and animal, remaining just as the Creator moulded it over the mountains and valleys. Nature is said to be an open book to those who really wish to read it, but there are grades and shades of meaning which may be hard to understand. There is certainly no place where the leaves are more widely spread or the print more clear than in these portions of the book.

With all that has been done by geologists and other scientific men, by central administration of the government, and by officials concerned with immediate administration of National Parks, we have only begun to convey the really great lessons to the multitude. Science needs itself to know more fully what the story is, and then

simplification and clarification must help to carry the great essentials over, so that the casual visitor may read and may interpret without depending upon the word of another. To attain such clearness of expression is to stand upon the highest plane of education. For many objectives this level can nowhere be reached so easily as in the National Parks. There are not in America other places where, for these purposes, comparable possibilities for effective adult education concerning nature can be found, with the grandest products of creation themselves as teachers. For utilization of this opportunity we need support adequate to prepare for most effective use. In such a super-university professors would be only guides and not instructors, but there should be a faculty chosen from leaders in thought and appreciation, a group of men who, standing in the vivid presence of the Creator, would serve to point out the road.

But the parks may not be pictured solely in a setting of science as it is commonly known. In ways we can define only imperfectly they express peculiar elements of beauty and grandeur which lie beyond the realm of formally associated facts and logic. Partly does this attractiveness reside in that which stirs emotions through influence of æsthetic and artistic values, partly it is recognition of sublimity in the power and order behind nature.

I remember standing last summer facing the great mountain range at Glacier Park, thrilled with the living charm of forest and meadow and the cold brilliance of snow-field and glacier. But behind the splendor of this mantle over nature there was clear revelation of the movement of creation—shown in the body of the range which had been lifted and thrust forward many miles above the level of the plain on which I stood. This act of building was the source of glory in the mountain. The overwhelming bulk and strength of cliff, with appeal of lake and glacier, represented only residual evidences of power exerted in this great work. And the garment lost nothing of its beauty through knowing of the majesty it clothed.

While the National Parks serve in an important sense as recreation areas, their primary uses extend far into that more fundamental education which concerns real appreciation of nature. Here beauty in its truest sense receives expression and exerts its influence along with recreation and formal education. To me the parks are not merely places to rest and exercise and learn. They

are regions where one looks through the veil to meet the realities of nature and of the unfathomable power behind it.

I can not say what worship really is—nor am I sure that others will do better—but often in the parks, I remember Bryant's lines, "Oh, why should we, in the world's riper years, neglect God's ancient sanctuaries, and adore only among the crowd, and under roofs that our frail hands have raised?" National Parks represent opportunities for worship in which one comes to understand more fully certain of the attributes of nature and its Creator. They are not objects to be worshipped, but they are altars over which we may worship.

I have said that National Parks hold their place as areas for recreation and education; that unlike National Forests their protection is not supported by economic value. Today one of the questions of most critical importance in consideration of National Park policy concerns what is known as "complete conservation," or protection with all natural features unimpaired. In my judgment, not alone recreation as commonly interpreted—not even education in its routine aspect—can guarantee unbroken maintenance of primitive conditions in National Parks if great economic resources are involved, since both recreation and education have been made to operate along with economic use. But a function of such importance as to insure complete protection is, I believe, given in abundant measure through the higher educational and spiritual values, which offer the greatest and most noble uses to which any possession may be put.

It is necessary that in all cases the problem of preservation of park areas be viewed from every possible side. Every known need must be examined, and final decisions must be made in accordance with the most fundamental requirements. We need never hesitate to submit a good case for judgment. In recent study of possibilities for saving outstanding groves of redwood forest on the Pacific Coast initial discussion of the project found all of the timber areas involved already in private ownership and marked for use in important economic operations. Consideration of the higher uses for these groves has brought about a situation in which the need for setting aside the finest regions for these purposes has been universally recognized, and the industries concerned have aided in working out a plan by which the desired areas may be protected.

The Federal Government we see then as responsible for preserva-

tion and administration of National Park areas unequivocally unique and of national importance for the higher purposes. So far as they can be used advantageously, the Federal Government also carries responsibility of administration for accessory recreational and educational purposes of those public lands held primarily for economic use, as in National Forests and other reservations.

States and municipalities will meet a very large part of the general need for recreation, partly by lands dedicated to that purpose alone, and partly by areas to some extent in economic use. Location of these lands of states and cities will be planned carefully with relation to all economic requirements, in order that they may serve their purpose most fully and with least interference in caring for other vital needs.

In this discussion the utilization of recreational areas such as those included in State Parks and Municipal Parks for educational and other purposes has not been given special attention, although the values represented in these directions are very great. Discussion of the specific problem of State Parks in relation on the one hand to Federal reservations and on the other hand to Municipal Parks is to be considered by another speaker in the program of this Conference.

INSPIRATION AND EDUCATION IN NATIONAL PARKS

The need of education is never met merely in accumulation of facts. In some of its most important aspects education is essentially inspirational. It is through this form of expression that it exerts the largest influence in stimulation to constructive thought and in forming of ideals. Inspiration can develop in the lowliest types of effort. A bricklayer may take such pride in learning to lay a wall that his work becomes artistic. In general it is from great or outstanding sources of influence that inspirational education arises.

Human interest in natural phenomena, whether from the point of view of the lover of nature, the investigator, the teacher, or the preacher is of real significance only when the individual is brought face to face with reality, and forms his judgments on the basis of observation. Great teachers sometimes utilize the most commonplace materials in such a manner that the message carries without possibility of misunderstanding. Similar effects may be produced by great expressions of nature which explain themselves by striking contrasts or aspects so unusual as to make their interpretation unavoidable.

Recent study of means by which the average intelligent person may increase appreciation of nature has indicated the importance of great opportunities for self-teaching. In the field which touches natural features of the earth, we discover that a tremendous influence can be exerted by adequate utilization of such resources as Niagara, the Grand Canyon, or the Yosemite. In the presence of these extraordinary aspects of nature, it is possible to widen and deepen our knowledge in such a way that the enlargement of thought or mental vision becomes a permanent condition, making possible fuller understanding of many things which might otherwise seem less striking.

The Advisory Board on Educational and Inspirational Uses of

National Parks Bulletin, vol. 9, no. 53, pp. 3–5, July 1927.

National Parks was established for the purpose of securing the best judgment possible from leaders of thought in education, science, and study of inspirational values in Nature. It was intended that through this body careful examination be made of fundamental questions in education and research which have bearing upon the great problems presented by National Parks. It is recognized that many important approaches are now being made to the study of these questions. The program of the National Parks Service, and that of many cooperating institutions, has been directed toward development of adequate means for meeting public needs and for using the enormous assets of these parks to greatest advantage. The work of this Advisory Board must be considered as only supplemental to other efforts, but it will be directed more specifically toward examination of the basic questions relating to general educational policy as it concerns the public interests of America.

In consideration of the value of National Parks as outstanding opportunities for inspirational and educational work, I have already discussed certain phases of the subject in an earlier number of the National Parks Bulletin. There is perhaps reason for quoting this statement here, rather than to present the problem in another form.

"For many purposes the purely educational value of our National Parks is far beyond that of any regularly-established formal educational institutions. Among the most important features are those which concern the nature of the earth—the manner of its building—the forces which have come into play—the meaning of the almost limitless history of earth-making as it is pictured before us. The work of the Creator's hand presents itself here in such a way that all may comprehend. Here is found also much that represents the unmodified primitive life of the world, both plant and animal, remaining just as it was moulded over the mountains and valleys. Nature is said to be an open book to those who really wish to read it, but there are grades and shades of meaning which may be hard to understand. There is certainly no place where the leaves are more widely spread or the print more clear than in these portions of the book.

"With all that has been done by geologists and other scientific men, by central administration of the government, and by officials concerned with immediate administration of National Parks, we

have only begun to convey the really great lessons to the multitude. Science needs itself to know more fully what the story is, and then simplification and clarification must help to carry the great essentials over, so that the casual visitor may read and may interpret without depending upon the word of another. To attain such clearness of expression is to stand upon the highest plane of education. For many objectives this level can nowhere be reached so easily as in the National Parks. There are not in America other places where, for these purposes, comparable possibilities for effective adult education concerning nature can be found, with the grandest products of creation themselves as teachers. For utilization of this opportunity we need support adequate to prepare for most effective use. In such a super-university, professors would be only guides and not instructors, but there should be a faculty chosen from leaders in thought and appreciation, a group of men who, standing in the vivid presence of the Creator, would serve to point out the road.

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The first work of a body such as that set up by the National Parks Association must concern itself with two aspects of the problem of inspiration and education in the Parks. First, a general statement of the broad principles or ideals which we may recognize as those which should naturally guide in a program of educational or inspirational type in National Parks or in any other region; second, the working out of definite illustrations which may serve

as concrete examples representing the highest use of available materials.

For present purposes of the Advisory Board there seems to be no more effective method of study of our problem than by utilization of the program for educational and inspirational use of the Grand Canyon as it is being worked out by cooperation of various agencies, including the American Association of Museums, and the Committee of the National Academy of Sciences working in cooperation with the Geological Society of America and the National Research Council. This program is being realized by a Committee of men who have been concerned with intimate study of the Grand Canyon problem. It presents one of the most extraordinary opportunities in the world for expression both of the general principles involved and of their application in detail.

The features of the Grand Canyon which it is planned to illustrate will be represented by fifteen or twenty localities clearly visible from Yavapai Point. These stations will be pointed out to the visitor on an exceptionally useful relief map and will then be seen in detail in the Canyon through a telescope. They will thus appear with the perspective of the whole Canyon about them. The localities will be represented at the observation station on Yavapai Point by specimens of the original materials brought up to the station. The localities will then be made accessible by special trails. They will also be described in a small, clearly written, fully illustrated publication available for all who may desire to read.

It is proposed to tell the story of the Canyon in such a manner as to illustrate the meaning of its development. The outline will be divided according to the following groups of exhibits:

1. Evidence of disturbance of the earth's crust as illustrated in faults and other unmistakable proofs of instability or movement in past periods. It is recognized that such a statement is necessary not only to show the nature of the crust of the earth upon which we live, but also to make clear how the walls of the Canyon were built and how the gorge was cut. It is through movement of the earth's crust that basins for accumulation of deposits are formed. It is through movement that great cycles of erosion are initiated. It is through movement of the crust that present features of the earth's surface, and in part the climate, were determined, thus leading to development of existing variety in physical conditions, reflected in the variety of life.

2. Building of the Canyon walls. Evidence indicating the manner of accumulation of sandstone, conglomerate, limestone, and other formations piled up for ages and represented in the layers of the Canyon walls.

3. Evidence indicating the method of cutting the Canyon. This will be shown, first, by illustration of a bar on the river at the bottom of the Canyon, consisting of boulders, pebbles, and sand, which are the tools by which the cutting has been carried out, and the swift water of the river is the power which has driven the blast.

4. The story of life of the earth as represented in the great succession of strata in the Canyon walls, illustrating the nature of the life at different periods and its changes through the ages.

5. The variation in present-day life as it is spread over the Canyon region, adapted to different altitudes, different types of climate, and other physical conditions. This illustrates the relation of life to its surroundings, a relation that is of interest when considered in the light of what is shown in the history of life recorded in the Canyon walls.

6. Aspects of the Canyon which are of exceptional artistic, inspirational, or spiritual value. The Canyon as seen through the eyes of great scientific philosophers, great artists, and great interpreters of human interests. In the practical sense this means the pointing out of localities from which exceptional aspects of the meaning of the Canyon can best be understood.

Many of the exhibits have already been worked out. An attempt to plan the series has made it clear that as yet the scientific world is only in part acquainted with the phenomena expressed by the Canyon. This has led to much research, which will necessarily be continued. The planning of the exhibits and their use will be a real stimulus to fundamental scientific work and to its interpretation.

A statement regarding progress in development of the series of exhibits at the Grand Canyon will appear in the next number of this Bulletin.

A NATIONAL PARK CREED

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THE CONTRIBUTION OF SCIENCE TOWARD THE APPRECIATION OF NATURE

Mr. President, members of the Society, and distinguished guests: May I first, Mr. President, congratulate you and the Society on your great achievement in the production of an institution which stands first for research and second for the educational development—a combination which represents, as I always see it, a rare relation because only too frequently these two subjects are separated. I come, Sir, from an institution that is devoted to research. We hope, however, that the results of our work will also find their way to the people through some process of education. I recognize that when you take over the duties of a great museum, in addition to those of investigation, you assume a great charge, financially and in the work of your Staff. Therefore you deserve the honor, the felicitations, the congratulations of other institutions which have not carried the burden. I wish you all success in your venture.

Mr. President, on an occasion such as this when the problem to be discussed is that of a museum, I realize that I am not an expert. I am preceded by President Osborn and Dr. Sherwood and followed by Dr. Bumpus, all of whom have devoted themselves specifically to this subject. Therefore, Sir, I have chosen to talk upon one aspect of the problem which I notice is mentioned in President Osborn's address; that is, the application of certain of these things which you discuss to the problem of what I might call the companionship with nature on the part of the average individual in average everyday life.

My subject is "The Contribution of Science Toward the Appreciation of Nature."

I imagine that when I attempt to speak on a subject of this kind I almost always begin with a classification and that people have

Address at the formal opening of the Buffalo Museum of Science, January 19, 1929. *The Buffalo Society of Natural Sciences, 1861–1929, Sixty-eighth Annual Report, July 1, 1928–June 30, 1929*, pp. 7–12, 1929.

noticed that it is almost always in threes. On this occasion I have thought fundamentally of the problem as concerning three aspects of what we see about us: Man as an individual and the way he looks at things; other people and the way we look upon them; and nature or the rest of the universe.

One of my friends says that the reason we attempt to classify things in threes is that the custom dates back to a time when that was as far as people could count, but at any rate I always start with that arrangement.

On this particular occasion what I wish to do is to consider the relation of the individual, not so much to other persons as to nature about us.

Now, nature, as I think of it, represents precisely what I see in the Museum here; that is, the elements of the universe considered from the point of view of natural science, beginning with basic physics, and running through geology, biology, and up to the classified works of man as they are studied from the point of view of the investigator.

Appreciation of nature is not an easy thing to express, and perhaps I had best not attempt to define it more than to say it represents to me that interest, that solace, that joy, that stimulus which we receive from contact with nature as we see it about us, either in our investigations or in everyday life.

When I think of the problem in this sense I almost always go back to the question which has been expressed in many types of publications; that is, what is the relation of man as he rests in his environment of nature? And here there comes to me the story recently told by a friend who went out into one of those most remote corners of the Navajo Reservation to a place that some of you have seen in the Canyon De Chelly; that is, the White House. He was not able to go up this magnificent canyon because the sand was too deep. So they rode on horses along the edge of that magnificent cliff, with its roseate rocks that reflect the light of the sun in a most extraordinary way, and finally they came out on a high point. There they looked across the sandy wash to the eight-hundred-foot cliff on the other side, in the bottom of which in those great recesses were these magnificent buildings of ancient times known as the White House. And they stood there for a long time looking at this perfectly magnificent work, with the background of

nature behind it. And then a Navajo came out from a little side canyon and stood on a rock in front of the White House and sang a song; and my friend said: "From the whole of my experience in that long trip this was the most magnificent thing—the story of man, with the great background of geology behind it, and then the expression of a living being illustrating the thought and the life of the people." And I said, "Why was that so wonderful to you?" And he thought a while and said, "I do not know."

Some days ago I saw the same suggestion, which probably all of you read in the *Literary Digest.* A girl, I think a high school girl, somewhere here in the State of New York was asked why these things be. I can't remember the poem exactly, but she said:

> "I do not know how such things be . . .
> I only know a maple tree
> In late September dims the eyes
> With sudden tears . . ."

Nor do we know why, excepting that there is a peculiar relation between the imaginative characteristics of human beings and that which develops in us when we are in contact with nature in its most primitive, in its simplest, or even in its most fully analyzed form.

What is nature to us? That depends, I suppose, on whether you are an investigator or whether you are a primitive savage, or perhaps neither. I perhaps have been a primitive savage in my earlier days. I presume other people may have assumed that would be the case in my early childhood. I cannot say what the reflections of a primitive savage would be; but as nearly as I can determine from what those who have studied the problem tell us, the world of nature is to the savage a complex of marvelous forces which he doesn't understand, and he confesses that to be the state of his knowledge.

I passed through the state of collegiate education many years ago, when colleges taught mainly by the use of textbooks. I acquired from that college education an extremely interesting series of interests. My first reaction was that of strong repulsion against the teachers who attempted to tell me, from books in which they had read, about things which I knew they understood little. So I came away with a distinctly inquiring type of mind. Had I been given

a good education I might never have become an investigator. I came away with the feeling that I would like to know about these things, and that has been my interest since that day.

Now there is only too great a tendency in these days of having everything organized, from business to knowledge, to attempt to put all that we know in the form of formulae and to hand it over to others who will absorb the formulae without perhaps ever knowing what they mean. Today I think we have passed the stage of the commonplace book type of education, and your museum is an indication of the thing that we expect in the future.

We have passed the Main Street in which everybody accepted what appeared in print. We have come to the time when we accept the thought of great people. We love great books. We reverence great teachers. We look upon great museums as places in which and through which we come in contact, not with a stereotype nature, but with nature in its simplest, clearest, most real form.

If I were asked what science brings to us—jumping over many other questions which might be asked—I would say that science today first of all brings the clearest expression of the reality of nature that man has yet known, and yet that reality is not the clear certainty of the textbook stage of American education. It is a recognition of the fact that we only know in part.

I remember when in chemistry everything was perfectly clear. The molecules were packed in groups, and the atoms each had their place, and a rock was a rock, and material was material, and mind and all other things were so totally different that there could be no relation between the two.

These days, when I sit with the great physicists and ask them their opinions, I find that the farther they go with their investigations the less they know about what matter is, the more distinctly energetic, the more distinctly spiritual it becomes, until today it would be unsafe to set up a definition of matter such as we accepted without question forty years ago.

Today, with the physicist and the astronomer cooperating, we have reached out so far into space that we have to use conventions, like distance measured into time and years that it takes light to travel at 186,236, or whatever miles it is, in a second. We have come to a realization that science will probably never penetrate the boundaries of the universe, nor are we likely to penetrate the inner-

most realms of the electron or, if you wish, the nucleus of the atom. In other words we are faced on each side, above and below, far out and far in, with limits which it seems improbable that we shall pass.

It is the same way with time. The geologist does not deal with the great spaces of time with which the astronomer plays, yet the geologist has given a concept of time as we see it passing, as you see it when you look over the edge of the Grand Canyon, and when you see before you, with all the reality of the present moment, stage after stage in history, in each of which you can feel as much at home as if you had lived in that period. You see the sands on the shore of the Cambrian Sea, with the shells that lived and moved about in the water and with the prints of the feet of the Trilobitae that walked over it, pushing the sands to the right and to the left with their little extremities, and you are there upon the shore of the Cambrian Sea; and so on through all these stages, the reality and significance of each of which is clear, and yet you see them all at once.

Three days ago I asked a very distinguished geologist how much time he would give me for the series that I could see from the rim of the Grand Canyon, and he said: "A thousand million years, or more if you wish it." So that you stand there and see the clear realization of reality, the realization of actuality, the realization of movement through time of the great forces which were in operation. In other words you have time and movement together. Which brings me to the third concept—movement.

Science today gives us a clearer appreciation of movement—from the fast speed of the electrons and the atom up to the fast speed of the spiral nebulae or universes flying through space—and the tremendous significance of the movement of things through time in geology.

Now I come to the fourth concept; that is, of progress. This is something that was not clearly expressed in the world until modern science began to show that not only do things not remain the same for any length of time, not only do things change continuously through the ages, but as nearly as we can determine they change toward a more complex situation. In the case of higher organisms this means a more and more highly developed nervous system, and in terms of the highest expression of the nervous system it means

increasing intelligence, increasing capacity to reflect what is seen in the universe about us, increasing capacity to recombine the things that we see and to make out of them those things that we today call creative in the sense of thought.

So man finally comes to secure, through science, this great concept of movement through time and space and change that goes, as nearly as we can determine it, toward a goal that we cannot realize but which means betterment, so far as we are able to decide on the basis of the evidence that science has furnished us.

These are the things which science gives to us, in addition to what we could touch and taste, feel and hear before science began to organize and interpret knowledge.

Now one last word or two regarding the appreciational aspect of all this in the life of the average person. I can't attempt to tell you what you think about nature. Probably your reactions are like mine. Nor am I able to say exactly what I think. But the point that I want to make is that the contribution of science gives a vision of continuity of law which looks like purpose in nature, that makes our relation to nature all the way from the contact with the clod to the tree or to the mountain, in one sense, that of companionship.

Now of course companionship means an individual, and it means a human relation, and I am going to say frankly to you that probably the last thing in the world that we are ever going to know about is what a human relationship really means. It is the point of view of the individual, which is yours and mine, and there is no other way to interpret nature than by that.

I am inclined to think that the poets, scientifically inclined, have come nearer to an appreciation of what this means than any other group of people. I don't know, as I approach quoting poetry, whether I can always do it exactly, but what I want to say, lest I forget it, is that as I see science and as I see literature—all the way through from the taxonomic description of species up to philosophy and religion—I doubt whether there exists in our literature anything more beautiful than this hackneyed line in the beginning of Bryant's *Thanatopsis*. Lest you do not know, may I say to you that when Bryant wrote his *Thanatopsis* as a very young man he started off with the idea of writing a poem that had to do with death. You may recall the lines which he first wrote, which went with *Thanatop-*

sis—lines which indicated that the fear of death was inherent in the makeup of mankind.

The first edition of Bryant's *Thanatopsis* was the one that began with the words,

> " . . . yet a few days, and thee
> The all-beholding sun shall see no more . . ."

and went on in just that strain and ended with similar lines.

The first lines, those beautiful lines in which he asks you to go out and see nature and in which he indicates to you the beauty that you there meet—those lines were written years later, with the maturity of his contact with people and with nature. He added to his melancholy story the beauty of the opening lines and the beauty of the closing stanzas.

Another poet who has done a tremendous thing in the telling of the story of human life is Wordsworth. I should say that those who do not know the story of nature through Bryant, through Wordsworth, and through Shelley have missed a part of the most interesting philosophy of nature that ever has been written.

So it was Wordsworth who wrote those lines,

> "Thanks to the human heart by which we live,
> Thanks to its tenderness, its joys and fears,
> To me the meanest flower that blows can give
> Thoughts that do often lie too deep for tears."

So Shelley, as he looked at nature in the greatest of all his poems, as I see it, *Prometheus Unbound*, once came to write those lines where Asia speaks to the Earth with the words:

> "How glorious art thou, Earth! . . ."

And so I come to the last phase of the aspect of appreciation of nature as it comes to us through science, and that is that science has given us in the religious sense a universe deeper, wider, greater, more wonderful than anything that has been known before in the history of man.

One of the difficulties with the discussion as to whether we need a new conception of God or a new conception of religion today lies in the fact that people do not realize that original definitions of God, of religion, and of all the essences that go with them, were

made at a time when we knew less and when we were less careful about the definitions.

Man began with objectifying God in the form of graven images. He burned those and created for himself images of the mind in the terms of personality like ours. Today it is quite clear to us that the universe which we see is certainly less finite than that which man once knew—I cannot say more personal. But I am sure that those who constructed the original definition would be willing to say that the universe has grown beyond our description and that if there be something important behind it perhaps it is reflected in the lines of Shelley:

> "How glorious art thou, Earth!..."

And so, Mr. President and members of the Society, I think that in the development of your program you will lead not only to an interpretation of the laws of physics and of chemistry which may become of practical use in our making a living and clothing ourselves, but you will lead to a place where we shall have a higher appreciation of what we meet, if we are looking either at the spiral nebulae; attempting to find the nucleus of the atom; or merely enjoying the hills, the trees, and the flowers, as we see them every day.

Success to you in your undertaking!

NATURAL PHENOMENA AS A SOURCE OF INSPIRATION IN EDUCATION

It is not my idea to indicate that the whole of education is comprised in the word "inspiration," although I might go very far toward making a case for it. Nor is it my wish to suggest that natural phenomena are the only sources of inspiration. I wished rather to utilize a particular type of study which touches the problem of natural phenomena for discussion of the significance of the inspirational aspect of educational work.

I do not know that this body, or any other body, would accept any one definition for "educational program." I recognize it as comprising the means of determining adaptability or capacity of the individual to learning methods for work, attempting to find out what constitutes reality, and making certain that one learns to use imagination.

I realize that the disciplinary attitude of educational work is enormously important. I am quite convinced that it has been enormously overestimated in practically all educational programs. If there is any body or instrument that tends to close itself up tight and become completely impervious to whatever may be pressing upon it, the best illustration I know is the human mind when the attempt is made to pour information or knowledge into it. They say that a camel is able to close up the apertures in its head pretty effectively when a duststorm comes. That is nothing compared to what a young man may do when you attempt to teach him against his will.

I am quite convinced that the underlying principle of the mind in particular circumstances, the motivating principle is the thing of first significance, and if you can go far enough to make that motivating principle interest, then nine-tenths of the battle is already behind you.

I have not the idea that natural phenomena are the only things that may be used for development of interest or inspiration. I

Address before the annual meeting of the American Council on Education, Washington, May 3, 1929. *Educational Record*, vol. 10, pp. 272–276, October 1929.

know perfectly well that the world of human life about us represents the first interest to human beings. I am also aware of the fact that there is spread around us a very large thing called nature, which is commonly pretty much neglected, except for drawing upon it for natural resources, or in a few instances, as around this building, attempting to use the beauty of nature as a stimulus to interest in beauty.

I am quite insistent that in any educational process, the element of reality should have an important place. I say this vigorously and advisedly. I talk with too many young men and women going through the educational process, who live in a world that is almost completely imagination. They have hardly a foot or a finger upon the ground. They live in an atmosphere created by the textbook, or by the lecture, or by some formal process, rarely coming out to look upon the world of either human beings or physical things. I am a strong supporter of the idea that reality must not be something that is merely touched. It must be grasped by the fingers of the mind. Someone recently—perhaps Whitehead—referred to education as knowledge treated imaginatively. Knowledge must come through the mind, and must be treated by use of the imagination.

I am, on the one hand, insistent that we use materials as the basis of education; on the other hand, that they be treated imaginatively. I have chosen for the moment to utilize materials that come from the field of nature, although again, do not misunderstand me, I realize perfectly that nothing in the world matters to human beings excepting as it becomes a subject for human consideration or is treated in the human sense.

Having come out of a university, in which I enjoyed the experiences of an educator, in recent years unconsciously I have looked around to find where it would be possible to continue certain aspects of research in relation to education. Once a geologist, a student of fossils, of features of the land, of animal and plant life, and having been engaged in researches in national parks and forests, I gravitated toward study of certain of the problems expressed through the most striking natural features that we know in America. In the course of this work I have been led more and more to consider the significance of the inspirational aspect of the influence of these particular phenomena.

Ultimately, I have come to consider the significance of the inspirational aspect of education in national parks with relation to the inspirational aspect of teaching in the schoolroom. The principles are the same in both. I have stood firmly for the idea that those things which have become stereotyped through centuries of organization in education should be subjected to careful examination before they are allowed to come into use in the national parks.

When some of my friends say to me, "The proper way to proceed is to have models and diagrams and charts, with which you first instruct the visitor and then permit him to go out and see the thing that you have been describing and interpreting," I reply that thirty years of teaching indicated to me that the quicker I led the student to the thing itself, and then disappeared from the picture, the larger the percentage of result.

It was a very hard experience for me to discover that I was relatively a very unimportant element in the process; that if I could lead the student to the great natural feature—whether it was seen through the microscope or through the telescope, or whether it was merely a wide angle view of nature in the front yard—and let the student face the thing where he could see in some measure what it meant, where he could have the joy of personal discovery, there was the largest chance that he would come to the point of view that I wished to have him take.

It may not prove true that by this process the student would pass all types of examinations that may be set. It may be that, by memorizing rules and lists of names, he could obtain a higher mark. But with that system of examination which has to do with the development of his interest and his thinking, I find that, when he makes the discoveries himself and has the stimulus of interest from having found something previously unknown, he comes nearest to doing really fundamental thinking.

Last summer I visited fourteen parks and monuments and in each attempted to find what great things it represented. What are the great features in nature that parks are supposed to show; what are the lessons that they are assumed to teach? I came to the conclusion that even for this simple question there is great difficulty in securing an unequivocal answer.

I found that the visitors to the parks asked what might be called the natural questions relative to the greater things. That com-

monly they not only asked, "What is this, and how did it come to be here?", but they suggested that the situation had not always been as it is now, and that there had been a process of development leading to the present situation. Something had been pushed up, or something had been cut out. They were impressed, in the first instance, by the magnitude of the spectacle, by the height and depth and bulk. And that impression of bigness seemed to open up the sutures of their minds so that there developed an exceptional possibility for permanent intellectual and spiritual growth. In nearly every instance they asked questions which went much beyond their previous experience. Commonly the question was one which carried us quickly beyond the range of knowledge of all who had studied the subject. In the presence of a great natural feature which gave them a broadened vision of nature they were conscious of being lifted out of the commonplace, and of sensing the existence of still greater regions of knowledge beyond. At that point in the questioning of many the basic elements of what constitute science and philosophy and religion tended to be expressed together.

The influence of these contacts upon the average person is sometimes called "inspiration." Far be it from me to attempt to define that term. All I mean is that the mind is opened; that inquiry reaches out in a new way; and that the result is a new viewpoint, which not only is a point of view but is an attitude of the mind which leaves it forever inquiring in that particular field.

A person who stands at Glacier Point, or at the foot of the great east cliff in Glacier Park, or at the edge of the Grand Canyon, has his mind opened by the inspirational process and goes out to inquire. Even if a part of the answer is never found he never ceases to ask questions.

A study of what happens in the parks makes me ask how far we can go toward applying in the schoolroom what we learn in the parks. I am not at all sure but that the magnitude of the opportunity to study this process in the national parks, where it is all on a great scale and the mind is open relatively wide, is an opportunity which may tell us much about what takes place in the human mind wherever or whenever great spectacles, things of great interest in nature or in human affairs, are opened to us, whether they be presented through a great crevice in the face of the earth

as at Grand Canyon, or whether they be made visible to us by the influence of a mind that with unusual power of illumination takes a clod or a fragment of a leaf, or a piece of a flower, or a part of a worm, and so illuminates it to the student that his mind opens and he sees and begins to inquire.

I have answered no questions. I wish only to ask assistance in attempting to answer those which I have asked.

Carnegie Institution of Washington, D. C.

PLANS FOR EDUCATIONAL WORK OF A PHILOSOPHICAL CHARACTER AT YAVAPAI POINT, GRAND CANYON, ARIZONA

The program designed to open to the visitors to national parks opportunity for understanding great natural phenomena brings to the representatives of the natural sciences a large responsibility for interpretation of these special features. Plans for educational work at the Grand Canyon include establishment of a station from which an exceptional view of the greatest features of the canyon may be obtained. From this station at Yavapai Point, one and one-third miles east of El Tovar Hotel, it is possible to observe the outstanding geological, paleontological and biological features of the canyon:

The plan as developed at Yavapai Point furnishes opportunity for direct observation of the most striking aspects of the canyon story, both with and without the aid of telescopes. There is also arrangement at the station for study of specimens brought from the principal localities. There is also provision for guidance by a trained naturalist and instruction as to ways by which the several localities of peculiar interest in the canyon may be visited.

One of the outstanding opportunities involved in this arrangement for study of the features of the canyon lies in the fact that there is shown here the interrelation of the many types of phenomena. There is expressed in an exceptional way the unity of the processes in nature through which the geological, paleontological, and biological features have been produced.

Abstract of paper presented at the forty-second annual meeting of the Geological Society of America, Washington, December 27, 1929. *Bulletin of the Geological Society of America*, vol. 41, no. 1, p. 105, March 31, 1930; *Pan American Geologist*, vol. 54, no. 2, p. 135, September 1930.

REPORTS ON STUDIES OF EDUCATIONAL PROBLEMS IN NATIONAL PARKS

Suggestions Relating to Purpose and Educational Program of Crater Lake National Park, 1929

Not at any stage in discussion of the purpose and function of Crater Lake does there seem to have been question regarding the general purpose in dedication of this area as a National Park. The crater and the lake have always been the distinguishing features. Analysis of the characteristics of the lake and its surroundings brings out two special characteristics: (1) The extraordinary beauty of the lake expressed more particularly in its color. (2) The exceptionally interesting geologic or dynamic aspects of the volcanic mountain in which the lake rests.

The first feature may be characterized as an exceptional expression of color, with atmosphere produced by varying lights and shadows arising from the quality of the sky, the nature of the clouds, and many other features. The second is an unusually clear illustration of the effect of volcanic activity, the essential element being dynamic, and representing one important phase in the history or development of the earth.

Along with the two outstanding features of the Crater Lake region there are many accessory factors of much interest. Such are the beauty of the hemlock forests, the nature and distribution of the flora and fauna in the immediate region, and the extraordinary outlook from the mountain over a surrounding region of great forests and mountain peaks. The setting of Crater Lake, as it were on the backbone of the Cascade Range, in a region presenting the results of tremendous volcanic activity as seen in the lava flows and in the volcanic cones, is of importance in considering the general problem of the mountain in which Crater Lake rests.

The administrative policy of Crater Lake National Park must center itself upon furnishing opportunity to enjoy and appreciate,

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first of all, these special things—the beauty of the lake with its exceptional setting in the crater, the dynamic story of the mountain, and the forests growing around and upon it. The program must combine three principal types of effort: (1) The development of avenues by which the public may reach the points at which the beauties and wonders of the region present themselves to best advantage; (2) the making available of means through which the public can obtain essential information regarding the nature and history of the crater and the lake; (3) the providing of such necessities and comforts of living as will permit the visitor to secure maximum enjoyment of the peculiar features of this park.

One of the greatest needs concerns the making available to tourists of essential information regarding the nature of the mountain, and the history of its making, as a part of the story of tremendous igneous activity of this region. It is essential that we bring the visitor into contact with those features indicating the reality of the crater as the result of an actual series of events in history of a volcanic mountain. It is desirable to proceed as far as our knowledge permits, with an interpretation of the events which have brought the crater to its present state and have made possible the origin and the exceptional development of beauty in the lake which it holds.

In preparing a plan for educational work at Crater Lake it is essential that concise definition be made of the principal elements of interest, both in the story of the crater from the geological, historical, or dynamic point of view, and covering the principal features involved in the origin and nature of the beauty in the lake and its environment. While it is desirable to have available in well-organized and simplified form all scientific data regarding the history of the crater, it is necessary that from this material there be selected those things of exceptional importance because of the possibilities for appreciation of their reality, because of their accessibility, and by reason of the bearing which they have upon interpretation of the dynamic history of the crater.

As the objective of this program concerns presentation to open-minded persons of materials upon which they themselves can judge, it is desirable to find a locality from which the features to be the objects of principal discussion can be observed together and under most favorable conditions. Such a locality is possibly presented by Victor Rock.

An educational program at Crater Lake should provide the following:

1. A plan of roads and trails designed with special reference to presenting the features of the region which have been determined by experts to be of outstanding importance.

2. An adequately equipped observation station situated on the best available point for study of outstanding parts or aspects of the crater and the lake.

3. A staff of persons competent to study the region effectively, and to take charge of all educational work on the ground. This staff should prepare the publications needed for use of the public, and take charge of necessary talks or lectures. There should be a Naturalist in charge at a salary of $3,000 to $4,000 per annum and an assistant at $1,800 to $2,400 per annum.

4. Talks or lectures designed to assist in informing large groups of visitors as to the objects of principal interest in the region, and how they may best make acquaintance with them.

5. Conferences and walks for interested visitors who desire guidance and assistance of competent naturalists.

6. A series of publications representing two types: *one*, a relatively full but clear statement, scientifically exact and discussing the principal features of interest in the Crater Lake region. A *second* type of publication should be a small booklet, which might be broken up into leaflets, each of which would treat of a special feature. This second type of publication should be of such simple form that in the course of examination of any particular locality the visitor could obtain the major facts of interest within this space of two or three minutes. The booklet and the leaflets should be illustrated with the best possible photographs and drawings.

The *observation station* should be so situated as to give one of the outstanding views of the crater and the lake. It should be equipped with specially selected materials by use of which the story of the crater can be told to best advantage.

With the living accommodations located approximately as they are at present, the best available point for such an observation station and museum seems to be Victor Rock. It should be approached over a carefully constructed trail from the rim of the crater. The rocky point should have built upon it a platform approximately 25′ x 40′, with a carefully designed parapet and, if

possible, a sheltering roof of such a nature that it would not be conspicuous from points around the margin of the lake or the rim of the crater.

The station should be equipped with several telescopes. Some of these must have sufficient field to show the location of objects of principal interest in their setting. At least one telescope should have sufficient power to give the maximum opportunity for careful examination of distant objects. There should also be available such maps as would be needed to show all the details of the lake and surrounding region. If possible, a relief map should be prepared for use at the station. Finders locating points of interest would also be useful. A small exhibit room back of the observation platform should contain specimens illustrating materials of peculiar interest at localities to be pointed out by the attendant.

A collection of the most significant plants and animals of the region with selected specimens illustrating the types of rocks may well be assembled in the Community House or in a small museum, in addition to facilities at the Victor Rock station. This collection should have as its purpose the interpretation of the region to those who are making its acquaintance, and would be of especial use in connection with general lectures given at the Community House.

It is important to provide for carefully prepared *general talks* to be delivered by a qualified naturalist at the Community House, possibly also at the hotel, and at such other places as may be suitable. These lectures should, in the first instance, outline the elements of major interest in the Crater Lake region with which the visitors would wish to make acquaintance.

Other *talks* of a more distinctly *special* nature might be given at the Community House or at the observation station. The lectures of the second type would be in effect the special discussion of things of particular interest rather than general descriptions of the region.

It is important that the lectures, wherever possible, be illustrated by carefully selected lantern slides of the highest type, and by the use of such specimens as can be utilized readily for the occasion. To this end there should be a stereopticon lantern of the best type at the Community House, and a set of lantern slides prepared particularly for general and special talks.

It is important to provide means for *walks* with scientifically trained guides in the immediate vicinity of the hotel and camps, for

the purpose of pointing out special views of the lake from carefully selected localities, and for showing through direct observation something of the materials forming the rim of the crater, and to give opportunity for making acquaintance with the elements of special interest in the flora and fauna.

In selecting a group of features to be used for interpretation of the story of the crater as it may be read from Victor Rock, it is desirable to present to the visitor the following points:

1. Evidence that the rocks forming the rim of the crater and the surrounding region could have been formed only through volcanic, igneous activity—in other words, they could have been produced only by the pouring out of igneous or heat-melted materials on the surface of the earth by way of volcanic eruptions. This proof would be based on examination of specimens of several types of rocks from the rim of the crater, such as volcanic glass, pumice, lava showing ropy or flow structure. If necessary, comparison could be made with rocks of similar types from known volcanoes—if possible those near Crater Lake such as Mount Lassen, or Rainier, or Shasta.

2. Evidence that the structure of the strata surrounding the crater is that which would be produced by pouring out of material from a vent or volcano. This would include evidence of the tilting of the strata away from the crater on all sides; also lens-like character of the strata; also evidence of flows of limited extent running out through old valleys on the sides of the crater.

3. Evidence indicating pouring out of lava from the old crater through vents or cracks such as are commonly formed on the sides of volcanoes, illustrated especially by the dike known as the Devil's Backbone.

4. Evidence that the layers of lava have burned or baked or otherwise modified strata over which they have been poured. (Possibility of finding evidence of vegetation on old surfaces of the mountain on which the vegetation has been burned or carbonized by pouring out of lavas upon it.)

5. Evidence of the Wizard Island cinder cone, both as to character and formation, indicating that it has been thrown out of a volcanic vent, as in the case of modern cinder cones. At some stage in the discussion there should be a general comparison in form and structure of this crater with volcanic vents for which the history of eruption is known.

6. After having proved the igneous nature and origin of the crater, it is important to consider specific stages in its development, as shown by the succession of flows of varying kinds, and such variation as is known in the character of the rocks. This would bring out the gradual building up of the mass, the variation of materials, both as to type of lava and as to difference between flows of molten lava and outpourings of tufa or ash. In this way the story of growth of the crater wall as a mass would be shown. If possible, evidence should also be presented showing any changes in the region about the crater, such as evidence of general quiescence during which the region may have been forested, or evidence of change of climate during which there may have been intensive glaciation of some of the older surfaces.

7. Evidences which concern the later story of the crater showing what events have brought about the present situation as to great width and depth of the crater with relatively low altitude, and evidence of almost continuously fractured inner walls showing the exposed edges of broken strata. The evidence here would include those suggestions as to the height or mass of the mountain such as may have obtained in a past period; also evidence on the one hand indicating that the present situation may have been brought about by explosion of the center of the mountain leaving only the sides and base, or evidence that the mountain may have subsided, leaving only the present remnants. Any available evidence should also be presented which indicates that the mountain may never have been a great cone, but that subsidence or sapping may have broken down the original walls until the present condition developed.

8. As a further chapter in the story of the crater it is important to bring out evidence of glaciation, and its bearing upon problems which concern the original size or height of the mountain, or which might relate to conditions in this region at a time when the climate of the earth was materially cooler and more humid than that of the present, as was the case in late Pleistocene time.

Although the story of the crater as it can be read from an observation station at Victor Rock will be one of the major features toward which attention of visitors should be directed by this station and the apparatus related to it, it is important to note that at the same time there will be great advantage in using the station for a study

of the beauty of the lake, and for discussing questions relating to the nature and distribution of life in that region.

The problem involved in examination of the lake as an element of beauty is one presenting many difficulties, but some of the questions concerned will always be raised, such as: what is the scientific cause of the deep blue color of the lake. It is important that in connection with demonstrations at the observation station all available data be brought together for use in presenting an answer to this question. This will involve information touching the composition and nature of the water, the elements of the problem based upon meteorology, and the psychological factors involved in a study of problems of this nature.

It is important that either in the observation station or in a museum situated elsewhere there be a simple but effective representation of materials illustrating the principal features of the fauna and flora which would naturally attract attention in a visit to the Crater Lake region. Some of these things of interest may possibly be shown from Victor Rock with the naked eye or with low-power telescopes. It is desirable also to have available information as to means by which persons who wish to do so can reach all points of interest seen from the observation station.

Suggestions Regarding Educational Program of Grand Canyon

The educational program of Grand Canyon National Park is as yet only in early stages of development as regards definition of purpose, program of operation, personnel, and equipment. As the principal features of the Canyon region appear well defined, planning for educational work would seem relatively easy, but intensive study reveals difficulties due in part to stupendous size of elements composing the picture.

Purpose

Although the purposes of educational work in the Canyon may comprise an infinity of subjects, it is essential that for use of the fleeting multitude of visitors there be outlined that group of features unquestionably distinguishing this area. The great number of details will inevitably be subject for inquiry by scientific and lay visitors, and a well-developed program must provide for answers to

such questions. Means for furnishing information will be presented through especially prepared literature, museum facilities, and personal interpretation by a well-informed staff of naturalists.

Study of what constitute major purposes in educational work at Grand Canyon has been the objective for carefully planned effort on the part of a considerable group of the leading scientific men of America acquainted with this problem. These results will be presented in a special statement to be issued in the near future. The essence of values from this study has already been incorporated in development of the station at Yavapai Point.

The idea of giving thorough study to objectives for educational work in National Parks has justified itself fully in examination of the Grand Canyon program. At any place of great wonders it is easy to pick out a large number of things any or all of which may be interesting to the public. But the object of this particular work has been conceived as relating to the exceptional opportunities which the parks present. It is, therefore, important to give assurance that a brief period which may be at the visitor's disposal can be in part devoted to the greatest available features.

Program of Operation

While the educational program of the park must arrange itself around the elements of principal interest, it will involve a study of the means for giving the best opportunity to see and to understand these most significant features. The educational facilities will necessarily be organized both according to methods of approach determined by geographical conditions, and to means by which information can be transmitted in the most effective way.

With reference to organization of methods of approach in the physical or geographic sense, the educational plan at Grand Canyon is relatively easy to define, as the main points of view are followed closely by the roads and trails along the north and south rims, and the trails from the South Rim to the floor of the canyon and from the canyon floor to the North Rim. In general the roads and trails as now established may be assumed to represent natural means of access determined by geographic features.

There can be no doubt that the future will bring out many new lines of study relative to points of view. Other roads and trails will be designed to bring out striking views of the Canyon with the

maximum of effectiveness and the minimum of damage to the landscape. It should be a part of the program of educational service to have such possibilities under continuous study. For this work it is desirable that every aspect of the program be included which has importance to visitors, including scientific, esthetic, and other aspects of personal interest.

The general program of educational work may for temporary purposes of classification be described under the following heads:

1. Definition of the general features or subjects of interest, the nature of which should be known to every visitor.

2. Selection of the major points of view and defining modes of approach by roads and trails or by other methods to be devised.

3. Plans by which visitors may, on their own initiative, obtain such general or orientation views as will present the major features in their natural relation to each other.

4. Installing of such necessary labels or signs along roads and trails as may call points of special interest to the visitor's attention.

5. Preparation of literature in the form of leaflets and simple guides giving concise information as to points of peculiar interest along roads and trails.

6. Organization of park naturalist personnel fitted to give information to visitors at selected points, and on special occasions, relative to features of major interest.

7. Planning of excursions by visitors (a) by way of concessionaire assistance through busses, private conveyances, by animals, with aid of guides; (b) through assistance of Park Service naturalists to visitors in their own conveyances, singly or in groups, and to visitors on foot, singly or in groups.

8. Carefully planned talks of stimulative and informative type to be given either under auspices of the Government at camp sites and specially selected auditoriums or in connection with activities of concessionaires.

It is essential that these several elements of the proposed program be always considered as only parts of a unit plan.

In general the attitude of the National Park Service by way of its Educational Division should be so to develop the opportunities for learning to know features of special interest in the park that visitors may exercise the maximum of personal initiative. At the same time it is important to make clear the desire of Park Service,

and of the concessionaires, to be helpful in promoting the enjoyment and furthering the interest of visitors. There is grave danger that in all programs for educational work the plans of visitors be so organized that the individual is moved about under guidance, and loses in considerable measure those values which come through the joy of personal discovery.

Development of these various aspects of the program might be carried out tentatively as follows:

1. *Definition of general features or subjects of interest, the nature of which should be known to every visitor.* The most successful of all European guide books have been those in which the points of major interest could be separated quickly and accurately from those interesting details which have generally a lower rating. The stars and double stars and triple stars have had great value to casual or hurried visitors. Even to persons giving more careful attention to the places visited, these outstanding points are recognized as those to which there is most frequent return.

In an area as large and with as many stupendous features as the Grand Canyon, it will be possible for any visitor to have an experience of tremendous significance through contact with even a small group of the features within reach. It is, however, important that every visitor on leaving the Canyon be able to say to himself, "In the brief time available I have had at least a view of those things of greatest interest and renown in this region." The study of this problem is one requiring the highest knowledge of the region, the greatest skill in interpreting the value of the features, and the most intimate knowledge of human interest and appreciation of natural features. Whatever the plan by which the educational program be developed, this highest thought, through which selection is made of the things of primary value, will have relatively large responsibility. The fact that the problem is difficult should not mean that it may, therefore, be set aside for some future time. The best effort should be made as early as possible, and the results then modified through further information as it accumulates.

In any list of outstanding features of the canyon it will be essential to include the following: (1) an exceptional panorama illustrating depth and magnitude of the canyon, (2) view of the Colorado River at a point where its power and volume are evident, (3) view illustrating nature of the great plateau into which the canyon is

cut, (4) residual peaks of Red Butte and Cedar Mountain, (5) bordering area of the Painted Desert, (6) contrast of the Archaean Inner Gorge with overlying Algonkian and Cambrian.

2. *Selection of the major points of view and defining modes of approach by roads and trails or by other methods to be devised.* What constitute the principal points of view at Grand Canyon will depend upon such a variety of interests and opinions that there will never be a plan so clearly defined as to go beyond the range of profitable discussion. There are, however, a number of places and points of view which come so near to universal acceptance that there can be no question regarding their need for special treatment.

It should be the function of the National Park Service administration, and especially of the Chief Naturalist, to carry on a continuous study of this aspect of the problem. The outstanding views should be selected by reason of combinations comprising the purely scenic and esthetic along with the scientific and spiritual values of these localities.

It is important to place emphasis on the time of day and the weather conditions which are particularly favorable for the best views. Certain points may have relatively little value in the middle of the day and be exceptionally beautiful in early morning or evening. A general guide to the Grand Canyon should list these places especially, and if the guide is so voluminous as to make impossible its thorough study on a brief visit, such conventions should be utilized as will make it difficult for the visitor to overlook these localities.

The leaflets prepared for trails and roads should be so organized and printed as to give special attention to the principal points of view. For bus and general trail trips it should be possible to select the special leaflets relating to the particular regions to be visited.

Roads and trails should be constructed in such a manner as to promote interest in the landscape and the features which they open to view. Means of access which form scars on the face of the landscape, or especially upon cliffs or canyon walls, are disfigurements difficult to erase. The planning of roads should not be merely the development of an engineering approach. The road is a part of the landscape and unless it contributes definitely to the beauty of the picture, it should come as near to being completely invisible as is possible. This should be accomplished under the most expert

and esthetic development of engineering art. It is not sufficient to say that the funds permit making only a particular type of a road. If the landscape is one for which it is worth while to spend large sums in opening it to view, it is sufficiently important to require that whatever is constructed be so handled as not to deface the very elements which it is expected to make available.

The constructing of roads and trails will inevitably develop as a special art involving the highest talent of the scientist, the artist, and the engineer, in order to show the great values and beauties of the canyon, without changing the face of nature through means used for access or through mere presence of the multitude in the region.

Due to the fact that the North Rim has been developed less rapidly than the South Rim, exceptional opportunity is open for special study of that area with reference to the points which have been made. Many extremely beautiful regions will be opened by new modes of access. Many other tracts should be left as nearly as possible in their primitive condition, and such entrance as is permitted should be arranged by way of trails constructed with the greatest care and under the highest development of artistic engineering skill.

Such view places as the points known as Havasupai, Mojave, Hopi, Grand View, Yavapai, Yaki, Moran, Lipan, and Comanche should be reached by roads and trails giving the principal effects of the view at the places where the greatest values can be reached. Such is true on the North Rim for Point Sublime and for several of the prominent locations in the region of Cape Royal.

3. *Plans by which visitors may, on their own initiative, obtain such a general or orientation view of the Canyon as will present the major features in their natural relation to each other.* Aside from views developed through roads and trails, which may be known as the unconscious approach, it is important to set up means for opening to visitors the most important views of principal features.

The consensus of opinion from careful study at the Grand Canyon indicates desirability of selecting two or more points with exceptionally comprehensive views, where the visitor may obtain an understanding of matters having special importance. It was believed desirable that these elements be seen in the perspective of the picture as a whole, and in such relation to each other as to

give maximum value through this setting. The plan as worked out has centered upon development of an observation station at Yavapai Point on the South Rim. A somewhat similar station has been planned for a comprehensive view at Cape Royal on the North Rim.

Although orientation at these stations would be largely by means of fifteen or more special views, good organization makes it possible to include most of the greater elements of the Canyon story, as well as to express the principles which underlie its interpretation.

Selection has been made of a number of other viewpoints somewhat less comprehensive and not so easily accessible for the larger group of visitors. For each of the subsidiary viewpoints the visitor would have full value for all information previously obtained from Yavapai Point or Cape Royal. In time special arrangements for orientation may be found desirable for the subsidiary points. In the absence of necessary apparatus it is desirable that the subsidiary points be fitted out with finders by which things of peculiar interest can be located, and that they be covered by preparation of special leaflets. These leaflets for special use should be related to the leaflet or booklet for description of the orientation panorama at Yavapai Point or Cape Royal.

For the station at Yavapai Point the views from the parapet cover the following elements of the Canyon and its story. The views as utilized from the parapet are numbered as in the list following.

Forces Which Produced Canyon and Walls:

I. How the Colorado River cuts its canyon
II. How the Canyon walls were built
  Movement of earth's crust makes possible canyon-cutting and formation building
  Evidence of movement in earth's crust
  Colorado River makes new formations from products of canyon erosion accumulated at its mouth

History of Earth Building:

III. Oldest rocks in the Canyon, and among the oldest in the world—so old that their original characters have been destroyed
IV. Oldest rocks which retain their original character as gravels, sands, muds, etc.
V. Greatest single geological story told by the Canyon

VI. Tremendous changes in surface of the earth, shown in widely differing formations of the upper Canyon walls

RECORD OF LIFE THROUGH THE AGES:

VII. Most ancient relics of life preserved in walls of Grand Canyon—primitive plants

VIII. Oldest remains of animals in Grand Canyon walls—crab-like creatures and shell-fish

IX. Earliest imprints of ferns and insects in Canyon formations

X. Oldest traces of four-footed animals preserved in Canyon walls—last to appear in the story

XI. Continuation of Grand Canyon story of earth history and life through isolated hill of strata upon Canyon rim

FORMING OF GRAND CANYON AS AFFECTING LIFE OF TODAY:

XII. Cutting of Grand Canyon as influencing variation of life by separation of North and South Rim Plateaus

Distribution of animals and plants today according to Zones of climate developed in cutting Grand Canyon

XIII. Life of the North Rim area, like that of southern Canada

XIV. Life of the South Rim area

XV. Life of the Canyon floor region, like that of desert areas in Sonora, Mexico

4. *Labels and signs along roads or trails.* Even if adequately prepared guides and leaflets are available, it is desirable that certain key points in the Canyon be so marked that one traveling without personal guidance can keep continuously orientated with reference to the landscape. Marking objects of special interest by labels or signs in a landscape such as that of the Grand Canyon presents a problem of difficulty, both as regards selection of features and with reference to the danger of detracting from their beauty.

As useful as labels or signs may be, they should not under any conditions be so placed as to mar the landscape or diminish the pleasure of the visitor. The situation requires a small group of carefully placed markers, serving to help in guiding the visitor to the elements of greatest interest. Careful handling of the problem will make it possible to keep the fullest attractiveness of the landscape. It is always important to bear in mind that one is dealing with a place of tremendous natural beauty, and not merely with a section of out-of-doors to be labeled as a group of museum specimens.

Along the roads on both the north and south rims it is desirable

to have a small group of markers indicating outstanding views and features of special interest. Important as it may be to give visitors a knowledge of the flora and of other individual elements in the picture, labels or signs furnishing information regarding trees or plants or particular rock specimens should be so unobtrusive as to be practically invisible for anything excepting careful inspection.

It is desirable to extend the system of trail and road markers to the north and east in such manner as to lead toward and connect with elements of special interest in regions beyond the park boundaries toward which visitors will naturally travel.

Labels or markers along trails and roads should be related to the system of guides and leaflets, as also to the plan for orientation, in such manner as to indicate elements emphasized by these other aids to visitors.

5. *Preparation of guides and leaflets for use along roads and trails.* Study of the Grand Canyon region will undoubtedly produce a number of published guides of varying stages of elaborateness, which will be considered from the point of view of different groups of visitors. For general use, whether for brief or for long periods, it is important to have literature with concise statements as to outstanding features along the principal roads and trails. It is desirable that this literature be so organized as to make it especially useful at the principal viewpoints.

The guide for use of visitors to orientation stations such as Yavapai Point and a corresponding location on the North Rim will give a basis of reference for literature relating to special roads and trails. Leaflets for trails and roads should be planned so as to place each item in its relation to the panorama of the Canyon.

A series of leaflets should be constructed with reference to each of the principal roads and trails. This should include a statement for the South Rim drive from El Tovar to Desert View and return, with special attention to each of the principal points of view along the road. Similar leaflets should be constructed for the drive from El Tovar to Hermit Rest on the South Rim, and for the North Rim drives from the hotel to Cape Royal, to V. T. Ranch, and to Point Sublime. Similar leaflets should be prepared for the Bright Angel Trail trip, Hermit Trail trip, the trail from Yaki Point to the river and return, and the trail from Phantom Ranch to the North Rim.

The leaflets should be so organized that the parts relating to

special stopping places could be looked over in not to exceed two or three minutes, so as to direct attention to the essential points at the moment of arrival. The data should be thoroughly tested scientifically. They should be clearly worked over with reference to their human interest, and should be presented in language so clear that it can be understood immediately. Simple sketches of the impressionistic type are desirable. They should center attention upon particular features as related to their environment. It is not wise to spread the illustration so liberally through texts and margins as to diffuse attention.

The leaflets relating to special view points should be so constructed that they can be obtained separately for a price not to exceed five or ten cents.

It is important that all guides, bus drivers, and other employees of Park Service or of concessionaires be thoroughly familiar with the data included in the road and trail leaflets. There should at least be familiarity with the object described, with its general significance, and with the available sources of information.

It is desirable that all visitors traveling on regularly organized trips handled by concessionaires be provided with leaflets covering the region to be visited. There would be advantage in having a leaflet for every trip furnished with the ticket for the particular journey.

6. *Organization of park naturalist personnel.* The element of personal relation to visitors desiring information is of enormous importance. No two visitors are alike as to interests, mode of approach, or supplementary questions which may be raised by the experience of the Canyon. The personal relation is valuable in that it permits deviation from stereotyped form of statement, and facilitates explanation of secondary features related to major aspects of the Canyon.

But we must note that there is advantage in so arranging the experience of making acquaintance with the Canyon that the visitor can make his discoveries with aid of roads, trails, road signs, and carefully prepared literature. It is therefore desirable to reduce instruction or talking at the visitor to the minimum which gives opportunity to enjoy the region.

In view of the fact that the Grand Canyon story represents a superlative development of nature, it will always be difficult to

find a naturalist staff competent to give information which will be scientifically and philosophically correct and at the same time intelligible to persons of average intelligence. It is not easy to describe the superlative in terms which are themselves less than the supreme effort of expression. It is difficult for one not saturated with knowledge and with interest in the miracle of the place to present a statement measuring up to the opportunity evident in the face of nature. It will always be difficult to satisfy any intelligent person with a purely scientific statement regarding a picture which clearly requires a philosophic interpretation, and which at the same time demands the highest type of spiritual appreciation.

Every educational system tends to develop what is known as the stereotyped view of the subject. If there is any place at which discussion of the material in hand will fail completely of its objective under a formal treatment, it will be under the conditions prevailing at Grand Canyon. It is essential that the naturalists have clear scientific insight, accurate philosophic judgment, and the sympathy of human interest. Formal instruction will be wholly unsatisfactory. It would be less advantageous than planning the general program of roads, trails, leaflets, and general approaches as leading lines, and leaving the visitor to follow his own interests.

For leadership in development of an educational program at the Grand Canyon, it is clear that no level of scientific, intellectual, and human interest would be too high. The subject has superlative scientific, philosophic, and spiritual interest, the picture smites the eye in such manner as to hold attention, and the audience is drawn from the most virile intellectual group of the country. Under these conditions the possibilities are too large to justify any guidance excepting that which lifts the spirit high. One has the right to assume that this experience may easily become a permanent influence in the lives of all who are exposed to the wonders of the region.

7. *Planning of excursions by visitors on their own initiative, or under guidance of Park Service, or under guidance of concessionaires.* Among types of excursions by visitors for which definite plans should be prepared, there may be listed: *First,* those organized by visitors on their own initiative and traveling either on foot or in

their own conveyances to points which may be indicated by aid of maps, guides, leaflets, or series of trail signs set up by Park Service; *Second*, excursions organized under guidance of park naturalists, and visiting points of interest either on walking tours or in their own automobiles; *Third*, the various types of excursions organized under management of a concessionaire. This third type would consist of riding parties along the rim or on the trails, regular excursions by bus to various points on either rim, or parties conveyed by special automobile transportation arranged and conducted by the concessionaire.

For the *first group* it must be recognized that the planning of excursions by the individuals who follow in a general way their own inclinations will in reality represent the development of leading lines toward points of interest which have been developed by careful study of the Canyon problem. Even under these conditions, the visitor will have a relatively large element of personal discovery in his experience. Excursions of this private nature will be influenced enormously by planning of roads and of trails, by the placing of guide signs and labels along the trails, and especially by orientation of the visitor through use of the stations on the North and South Rim, and by the leaflets extending interest along all roads and trails.

For the individual visitor there will also be much of profit in planning excursions through discussion of personal problems with naturalists at the orientation station, or at campfire and other lectures, or on guide walks and automobile trips.

It is important that special consideration be given to the interests of the individual following his own inclinations, and tracing out through his personal interest the methods of approach developed by previous study of the problem on the part of the administration.

For the *second group* of visitors, namely those attaching themselves to walking parties or automobile parties under the guidance of naturalists, it is important that there be, first of all, the experience of orientation from the stations on the North and South Rim, and second, the opportunity to secure the special literature relating to trips planned.

The *third group* of persons, carrying out their plans under guidance of the concessionaire, will represent a large portion of the total group of visitors. For their advantage it is desirable that the con-

cessionaire and the Park Service keep in close touch as to means by which all information available for the advantage of visitors may be used on the excursions.

It is important that all visitors in this group be provided with available literature touching points of principal interest along the road or the trail. It is also essential that all guides or drivers be acquainted both with the geography of the region and with the special literature describing it. They should also have acquaintance with the sources of further information relating to the area. It is also desirable that visitors on all trips of this nature have opportunity to visit the orientation station. If these conditions are met, even on a fleeting trip, it should be possible to learn the essential elements of the picture as it is met.

It is believed that cooperation of Park Service with the concessionaire can develop an extremely effective service through this third method of excursion. On the one hand, it must be recognized that there is the possibility of a routine trip with little explanation of value. On the other hand, there is the possibility of developing through the concessionaire extremely intelligent groups of guides and drivers in close touch with the naturalists, and fully acquainted with the means of assistance open to the visitor.

8. *Carefully planned talks on subjects of special interest to visitors.* It should be a part of the program of the naturalist staff to work out three types of carefully planned discussions for the information of visitors: (a) Regular, but brief and concise discussions of both general and special topics at the orientation stations; (b) general and special talks at campfires, community houses, and at other points where visitors naturally gather in the evening when it is not possible to enjoy the principal beauties of the Canyon; (c) talks arranged in cooperation with the concessionaire.

It is important to recognize the necessity of what might sometimes be called "selling" talks by the concessionaire for the purpose of informing the visitors of trips which may be to his advantage. It should be possible to arrange, in relation to such talks, authoritative statements regarding items of special interest in the Canyon. Such combinations may be of advantage both to development of the educational program and to development of legitimate and important features representing responsibility of the concessionaire.

It is desirable to use illustrative material in the form of specimens or pictures whenever this is possible.

All general talks should be in simple and clear form, and should

lay before the visitor groups of items of real human interest. The special talks should center upon objects accessible to the visitor, upon which a general interpretation of certain important features of the Canyon can be based.

It is essential that for all talks, of whatever type, the naturalist responsible be fully acquainted with the scientific detail of all materials considered. He must also have a clear, philosophic, and human view as to the significance of his subject. He must further have good training in the art of presentation of his materials; otherwise the subject will have relatively little value to the visitor.

Purpose and Function of Yosemite National Park: 1929

Intensified interest of recent years in parks and park problems, together with the need for large expenditures in their development and maintenance, has made necessary the attempt to define various types of park and recreation areas. It may never be possible to define any one of the types of parks in such way as to cover all possible questions for all places and all purposes. But the clearer the definition of purpose or function, the easier it will be to plan operation and development.

As contrasted with municipal and state parks, or with the extraordinary opportunities for recreation and education in national forests, the national parks are distinguished by characteristics which represent scenic beauty or natural phenomena unique in the country or in the world.

The evident purpose in the setting aside of each of the major parks leaves no room for doubt that it is the unique thing in the use of which the nation as a whole would wish to participate that constitutes the basic element in definition of national parks.

The characteristics of national parks have never been classified, and it may be difficult to reduce them to any simple form of definition. These areas are commonly included under the term of scenic or natural features. They have elements of exceptional beauty, and generally contain an unusual representation of primitive life of the region, both plant and animal. Generally the element of magnitude, as expressed by dimensions or power, is involved. In practically every instance the distinguishing thing is recognized as being an extraordinary clear expression of the type of phenomenon represented. It is usually true that the aspect of a given national park which distinguishes it from other areas has qualities

which give the visitor such a definite emotional reaction to the principal elements presented in its story that the effect may be characterized as inspiring.

There has never been doubt that the extraordinary features of magnitude and beauty of Grand Canyon, or in the evident power exerted in producing this phenomenon, exert upon the visitor an effect which makes inescapable a measure of recognition of the elemental laws of nature involved in the forming of the Canyon. There can be no doubt that observation of the Grand Canyon gives to the average person a deeper understanding of principles or laws widely expressed in nature, but which are usually difficult to understand or to appreciate.

A study of the major features of national parks indicates that while their use must overlap to a large extent that of other types of park areas, the development and defense of the system as of national significance must depend in the first instance upon emphasis on the features to which the parks owe their existence. While in general recreational and therapeutic values of national parks must be recognized as of interest and importance, there is no special reason why the nation should consider the support or administration of reservations for such purposes unless there be involved certain features which are of definitely limited extent and of clearly national importance. If it be true that national parks owe their origin to outstanding expressions of beauty, or to presentation of exceptional opportunity for understanding natural phenomena, it is through the utilization of these features that we must expect the National Park program to develop. There is, however, every reason to assume that along with the outstanding features of these parks there are collateral or related features which should be utilized and developed to as great extent as possible consistent with continuing emphasis upon the distinguishing characteristics.

In the history of Yosemite Valley there does not seem at any time to have been doubt as to the peculiar characteristics of this area. Along with climatic, physical, and biological features which may be duplicated in many other regions on the west side of the Sierra, the outstanding characters of the Valley are universally recognized as essentially of the inspirational or educational type. While everyone realizes that there are many accessory aspects which may have large value in association with the distinctive elements,

the things which have justified the existence of Yosemite National Park are represented in those features which distinguish it from the many other areas of exceptionally interesting mountain country of the inspirational type in the Sierra region.

Suggestions as to Distinguishing Characteristics of Yosemite Valley

Obvious features. 1. Striking features of magnitude shown in depth of valley and steepness or abruptness of walls.

2. The contiguous or surrounding region of high mountains with occasional slopes covered with snow or glaciers.

3. The exceptional contrast between abrupt, sheer walls of massive rock with their awe-inspiring expression of power and, on the other hand, the level areas of quiet meadow and forest. ("The hills rock-ribbed and ancient as the sun, the vales that stretch in pensive quietness between.")

4. The beauty and power of waterfalls, unique in their expression of living power which produced the valley.

5. The significant accessory features shown in widespread forests, meadows, lesser streams, and wild life enhancing the beauty of the region.

Less obvious features, representing the fundamental phenomena of nature. These represent elements in the region which may be in some measure sensed or recognized by a large number of observers. Their full understanding depends upon something more than casual inspection. They are within reach of the average observer, but only through the medium of extended study and the use of organized knowledge.

Certain of these features are in some part responsible for the emotional reaction described as inspiration. They represent aspects of knowledge in which human imagination extends itself through the medium of organized realities to an understanding far beyond that of mere photographic reflection of nature in the mind of man. The appreciation of these things is a natural function of the intellectual and spiritual life. The development of some of these characteristics represents a considerable part of the opportunity for growth in understanding and appreciation of nature.

1. The stupendous natural phenomena represented in the origin of the granitic masses out of which the Yosemite region has been carved. This includes the development or intrusion of tremendous

volumes of molten material forming the axis of the mountains and replacing that part of the earth's crust upon which the sediments of the foothills region originally rested.

2. The series of tremendous movements involved in the origin of the mountain region.

3. The enormous and extended erosion which has removed from the mountain region the covering sediments and has modeled the mountains through the power of water and ice.

4. The history of climatic change and the effect of glacial action in the glacial period.

5. The zonal associations of life, both plant and animal, as illustrated in the range of fauna and flora from the lower valley to the higher mountains. The illustration of life adaptation or variation in accordance with variation in physical conditions produced by altitude, temperature, and change in soil conditions.

6. The relation of variation in zonal distribution of living forms to the principle of specific variation in the plant and animal kingdom as expressed in the general theory of life development and variation.

7. The relation between movement of the earth's crust and change of land forms to variation of life through the ages. Recognition of the living earth as affecting the development of living things. The unity of the story of nature beginning with the causes which produce crustal movement and extending into the development of the living world.

8. Evidence that the phenomena illustrated in so spectacular a manner in Yosemite are forces which are active everywhere and through all time and are a part of the effective environment in which human life is lived. They also constitute a part of the material which man naturally uses in development of his environment to meet his own needs.

Suggestions as to development program. It is recommended that in development of the plan of Yosemite Valley special emphasis be placed upon opportunity for use and enjoyment of the Valley as represented in those features which have distinguished it from other types of parks and have given it its unique position among the National Parks.

While every way should be opened for use of Yosemite in the sense of possibilities of rest and recreation and enjoyment of living, the maximum opportunity should be given for understanding and

appreciation of the major or distinguishing characteristics of the Valley. Where judgments or decisions must be made among a number of possibilities involving use of the Valley, preference should always be given to those uses which relate to the basic purposes. If a study of the program indicates that sacrifice must be made among the possibilities of use, judgment should favor those forms of utilization which concern feasible combinations of recreational life and enjoyment with the higher intellectual, inspirational, or spiritual values. It should always be recognized that essentially man is an intellectual or spiritual being, and that where decisions are made between lower uses and higher uses, there can be no defense of any action which sets aside the higher uses at a place where these forms of utilization can be carried out to best advantage.

It is recommended that all possible consideration be given to development of the educational or inspirational utilization of Yosemite Valley along lines which involve use of those forms of guidance which present to the visitor the major interests or opportunities of the Valley, in the manner in which they may be most fully understood, appreciated, and enjoyed.

Interpretation of Story of the Granite Areas in Yosemite National Park

The form and beauty of Yosemite Valley are due in considerable measure to the shaping of its features in granite. Had the rocks of this region been the same as those of the lower Merced area, or of the Grand Canyon, the result would have been widely different from what we see in Yosemite today.

The mode of origin of much that has unique interest here gives reason for suggestion regarding the materials from which the valley is formed. Additional reason for making available to visitors something of the story of the granite at Yosemite is found in the fact that the circumstances relating to origin of the granite mass of the Sierra probably constitute the greatest single event in the story of the Yosemite region.

The account of building of these granite masses is an epic representing the action of tremendous creative forces. It possesses that attractiveness inherent in movement or development or growth. We need only to find means for presenting to the visitor observa-

tional evidence from which average intelligence can construct a picture of realities in the history of this region.

The essentials in presenting the story of development of the granite and its relation to the history of Yosemite involve finding such localities as will permit the visitor to see for himself the relation of the granite to the sedimentary masses into which it has been intruded. It is also desirable to present evidence of the sediment remaining in fragments above existing granite mountains.

Sentinel Dome. The best point of observation for telling this story seems to be the summit of Sentinel Dome. At this locality there is wide and unobstructed view over the whole of the Yosemite region and out to the Coast Ranges. From Sentinel Dome it is possible to see practically the whole range of the vast sedimentary series lying upon the granite and extending beneath the great valley of California. The general area of contact between the sediments and the granite is visible in the lower Merced valley.

There are also visible from the summit of Sentinel Dome a number of patches of sediment resting upon the granite at what has been called tentatively "Sediment Peak," near Mount Clark, also on Parsons Peak. Occurrence of blocks of altered sedimentary material near Sentinel Dome may also be seen.

The development of a station for the purpose of showing the granite involves preparation of a small smooth area on or near the summit of Sentinel Dome with equipment consisting of a well designed finder to locate the principal points of importance, a single case to contain a few important specimens and photographs with labels, and further a small booklet or leaflet giving simple and concise statement of the story and description of the localities to be observed. The station at the summit of Sentinel Dome should be approached by a path with as little as possible of artificial construction.

The case at the summit should contain specimens of the sediments near the contact in Merced valley, photographs of the tremendously folded sediments near the contact with the granite in Merced valley, and a few specimens from the sediments resting upon "Sediment Peak" and Parsons Peak.

The leaflet for use at this point should include a simple, brief description of the nature of the intrusion of the original molten granite mass and of its gradual cooling to take on its present physi-

cal characters. There should be a cross-section through the granite area extending out to the great valley and illustrating the nature of the contacts in the Merced valley and on the summit of the range.

The leaflet should also call attention to the erosion process by which the sediments were removed from the great granite area exposed. There should be reference to the old erosion surface of approximate Miocene time seen from Sentinel Dome.

Glacier Point. At Glacier Point the multitude of visitors makes it important to present, so far as possible, the story of the origin, nature, and significance of the granite mass which can be told to best advantage from Sentinel Dome. Although it is not possible to see the lower Merced valley from Glacier Point, the features illustrated from Sentinel Dome and not visible at Glacier Point could be represented through good photographs. There are many reasons why it may seem desirable to develop at Glacier Point a station which will show Half Dome and the Little Merced region, including the sediment cap on "Sediment Peak" near Mount Clark.

Museum. It is also desirable that in the geological room of the museum on the Valley floor the essentials of what has been discussed as important exhibit material for Sentinel Dome and Glacier Point be illustrated by use of carefully prepared transparencies, well selected specimens, careful labels, and a small leaflet.

Merced Canyon. It is also desirable that on the Merced canyon road near the contact of the granite and the sediments one or two small sign labels be set up pointing out the nature of the tremendously disturbed and folded sedimentaries near the point of contact with the granite. At such a locality it may be important to have a small case with a few photographs and labels. The leaflet used at Sentinel Dome would also be helpful in an explanation of what is seen at this locality. If argument is made that illustrating this point would obstruct traffic on the narrow road, suggestion might be made that the road exists in order to carry visitors into a region in which they are to learn something of exceptional wonders in nature. The distorted strata along the Merced road represent a part of this story, and there is abundant justification for so adjusting the situation on the road as to make it possible for visitors to park for the few moments necessary to come to understanding of this locality.

It is probable that visitors would make most frequent use of the

locality illustrating disturbed sediments in the Merced River region when on the way out from the Valley after having heard the story of the granite. If, however, they could visit the locality on the journey into the Valley, this would be helpful in understanding the story as it will be learned from the various points mentioned at Sentinel Dome, Glacier Point, and the museum.

Significance of Certain Biological Features in the Educational Program of National Parks, 1928

Although in development of the educational program of National Parks a relatively large part of the effort expended up to the present time has been directed toward study of life, the biological aspect of educational influence is probably much more important than has been recognized. A considerable part of the work done up to the present time has related to the more elementary features of field botany and zoology. It has been of real significance, and has served an important purpose through initiating study of the fauna and flora for many who under the conditions of relaxation in the park environment have welcomed a friendship with nature. Visitors to the parks commonly wish to have rest and freedom along with the desire to learn. There is an element of refreshment in the contact with flowers and forests and birds. It is a relation free from that routine of everyday life which the visitor especially desires to leave behind.

Among the major opportunities for education in biology, one of the most important concerns the factors which have to do with variation of life, and the relation between life and its environment. This is expressed in some measure in the geographical distribution of animals and plants, according to what are called life zones, representing a relation between variation of types of life and variation in physical conditions. Without reference to special theories advanced in discussion of the factors governing distribution, the relation between range of certain types of environment and the range of kinds of plants and animals is a striking thing in many parks. Through the suggestion and guidance of clear-minded naturalists, study of the illustrations here may bring about development of a train of interesting interpretations by visitors.

There is also in the geographical range of organisms in National Parks an extremely important relation between the distribution of

life zones and the development of the geography or geology of the region. The life zones have been made possible by geological changes resulting from contrast of two sets of forces: those involved in movements of the earth's crust producing uplift, and those expressed in wind, running water, and ice which have carved or moulded the land forms. The geological processes responsible for conditions governing distribution of life in the National Parks really represent one phase of the story of development of life through the ages. We describe them as physical forces. We do not know their origin fully. Perhaps the elements of the unknown in these activities are not less significant than those unexplained factors which elude us in study of the physiology and other life processes of the living organism.

The physical activity of the earth seems so intimately related to development of the living world that the two are in a sense one process. There are no places where these and many other relations of the story of life can be developed better than in National Parks. The beginnings of understanding may initiate with small details, such as are involved in distinguishing one interesting animal or plant from another. It is important to bring out these fundamental aspects of the life problem in connection with the educational program.

A further point of great importance in connection with study of the biological problem of National Parks relates to the opportunity to study unmodified primitive associations of plants and animals. This is increasingly important as we come to recognize that civilization is rapidly wiping out, or fundamentally reorganizing, a large part of the biological complexes of the world. The adjustment is taking place so rapidly that only under special conditions can we expect any areas to remain long with the composition of fauna and flora which existed when the parks were established. The time is not distant when areas in which the original biological grouping remains unmodified will have the same relation to the surrounding world altered under the hand of man, that a Pleistocene or Pliocene biological complex or association would have if somewhere isolated in the living world today.

The more deeply we study the living world, the more fully we recognize that what man has obtained from nature to meet his economic needs represents only a part of what might be secured.

The animals and plants forming the so-called domesticated group today are not the only ones that might have been domesticated. Their present status is due to a variety of circumstances, one of the most important of which is the fact that they are among the types long associated with man. Had the association been different the plants and animals domesticated might have differed in some measure.

It is to be assumed that with the increasing needs and intelligence of man, research of the future will bring to our service groups of organisms now largely known as wild or weeds. The existing fauna and flora may include many forms which man will need in the future, but which will soon disappear unless considerable areas are preserved intact—not merely intact as to certain species, but intact as to the whole association of organisms.

No better illustration is to be found of the need for preserving a biological group unmodified than that which has become evident in the development of forestry. We are just now beginning to consider growing new forests in the place of those cut. It is sometimes assumed that all we need to do is to plant a tree in the place of one removed. But a forest is not merely a group of trees of one kind. It is an association of plants including many types. In order to grow a forest such as has been harvested we must know the original conditions which we seek to duplicate. The only fully satisfactory situation for the future will be one in which we have original forests available for study of their composition, and of the many plants and animals associated in them.

What is true of the need for preservation of trees in a forest, so far as original association of organisms is concerned, is true of a large variety of associations of plants and animals regarding which we shall require information in the future.

In National Parks with a wide variety of plant and animal types, and with the biological zones most remarkably developed and related in their origin to geological phenomena, there is reason for attempting complete preservation of certain relics of plant and animal life associations for the enjoyment and appreciation of the people, and for future needs in scientific and economic studies. There is no doubt that such reservations will ultimately be enormously important sources of information regarding life, and con-

cerning the principles that controlled its development before man began to sweep over the earth and modify it.

Suggestions Regarding Significance of Problems in the Field of Geological Sciences in Connection with an Educational Program in National Parks, 1928

Much of the research and education which naturally develops in National Parks will relate itself to problems in the field of the geological sciences. In most instances, the great scenic features are fundamentally geological. Full value should also be given to the covering of vegetation, the beauty of the forests, and all wild life. Far too little has been said regarding these aspects of the landscape. It is, however, important to realize that in large measure the great characteristics of National Parks are of the geological type.

Under the circumstances, it is essential that the most careful study be given to the nature of the problems which must be considered in research and to the character of material to be presented in educational work in National Parks. Many of the specific features are of such a nature that they thrust themselves upon the attention of even the most casual visitor. Such, mainly, are the elements which have to do with magnitude and the figure of the land, which may be in sharp contrast to that with which visitors are familiar in everyday life. In addition to these obvious elements there are many things for which the visitor is not able to obtain anything like a complete interpretation. These great problems of the less obvious type represent material which it is of the first importance that we understand and present in simple but adequate form to the visitor.

With all that has been done in the general geological study of the National Parks there is still a vast number of details and of specific questions regarding which we have little or no data. This is true even in the strictly scientific sense without relation to educational application. It is important that preliminary to educational work there be intensive study on all of these questions and on the simplification of these data for educational use.

Experience in National Parks indicates that among the greatest of all questions that may attract the interest of the visitor are some

to which little or no attention has been given in the educational programs. The opportunity for study of geological problems in National Parks is one of the most important in America, and it is essential that there be leadership of the highest type for definition of the problems, as also for furtherance of researches, and guidance of the men to assist the public in understanding the material presented.

THE MEANING OF THE NATIONAL PARKS

Regardless of the state of opinion as to essential qualities of National Parks, no one doubts that this system includes a considerable group of the outstanding natural wonders of America. Question is never raised concerning the value of the Grand Canyon, Zion, Yosemite, Glacier Park, or Sequoia as pre-eminent examples of inspiring, informing, and rejuvenating influences in nature.

The elements of primary interest in these parks are of many types. They include some of the greatest known illustrations of magnitude, power, beauty, and antiquity. We know that their influence removes us for the moment from the wearing routine of the commonplace, and develops an attitude of mind favorable to enjoyment of thought on our greater personal problems. No one who stands in the presence of the inspiring spectacle of Grand Canyon, or the beauty of Zion, or in the midst of the life of past ages at Sequoia, can avoid an opening of the mind both to wider interest in the meaning of nature and to its deeper appreciation.

In another aspect these parks represent fully primitive nature controlled only by the conditions which produced the world as we have found it. Man's works may be great and beautiful, but they are built upon what creation furnished. There is always intense interest in finding the materials of nature and the expression of its modes of operation in unmodified form. In this contact with the full primitive we recognize also a peculiar freedom for appreciation and enjoyment of nature.

Visitors to National Parks commonly come with a desire for rest and freedom and the wish to learn. Few, if any, are without a definite measure of interest in knowing something of the unusual and inspiring things found there. In general the spirit is one of real inquiry. It is also clear that the visitor wishes to see and learn for himself, or through his own observation.

Although the stories told by National Parks are almost infinite in number, the distinction between these parks and other areas

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lies in the presence of features of special interest which attract the multitude of intelligent visitors. With increasing complexity of the problems involved in development of the parks, it is to be expected that, from time to time, attention will shift from one important objective to another, or may even direct itself for the moment to elements not involved in the program upon which the system really rests. It is easy to see that a feature which has to do solely with amusement, or another concerning the comforts of life, might become a lure to numerous visitors whose interest would initially have little relation to the main objectives of the park.

Over a wide range of subjects in nature the National Parks preserve for us illustrations of outstanding interest and clearness of expression. In each instance a great story presents itself in a striking way. In each case the story makes its immediate appeal through the inspiring influence of magnitude, or power, or beauty, and brings the visitor to question as to the cause. Nature unaided is here a great teacher, and the lessons are of unsurpassed impressiveness. But beyond the easy reach of interpretation for the untrained visitor lies a region of tremendous interest in appreciation of nature, for which the experience and guidance of trained and able men may help the visitor to a widened range of observation and understanding. In development of the National Parks system, full use and enjoyment depend upon the possibility of pointing out and interpreting the greater features which each Park represents. It is essential that every visitor know the major opportunities of his experience there, and how they may be used to best advantage. There should be full appreciation of the fact that adequate definition of these features will tax our resources of knowledge and expression. While one may sense the presence of great things, it is difficult to define or to describe them. As we stand in awe before the abyss at Grand Canyon, the geologist, the biologist, and student of genesis of scenery describe with measured exactness the events it represents, but in the end we find ourselves still struggling for expression of the essence of this greatness. Realization that complete definition is not attained does not relieve us of responsibility for making available to the eager ones something of what has been learned. We know that the wider the range of observation and of thought on the part of the visitor, the greater the opportunity for what Henry van Dyke has described as being lifted up "through wonder into joy."

THE UNITY OF NATURE AS ILLUSTRATED BY THE GRAND CANYON

In development of science adequate study of the vast accumulation of materials makes necessary a degree of specialization which will give to each student close acquaintance with the facts bearing upon his problem. A true picture of nature can be obtained only if the investigator sees every angle of the physiognomy of each object examined. In this acquaintance there must be assurance comparable to the ability we attain in recognizing instantly our neighbors across the street, or our associates in the office. This must be true, whether we are considering sea-shells from remote areas of the world, or infinitesimal constituents of the blood, or barely attainable elements of the starry heavens. Lacking such knowledge, the judgment of science would be open to criticism as resting upon superficial observation.

But intensive specialization brings serious consequences. The student of butterflies, whose soul is plunged into ecstatic tremors by the flashing wings of a rare species, may be wholly unresponsive to stimulation by flight of the swallowtail kite which throws the ornithologist into a state of great emotional exaltation. To both entomologist and ornithologist, the intellectual joy experienced by the pathologist in distinguishing from each other two types of almost formless bacteria may be almost incomprehensible.

Not only may the characters or criteria vary in different groups of things to such an extent that the problem of one student is not appreciated by those in other fields, but each researcher tends to dig himself into so deep a hole, or to fly so high or so far, that often the greater world, with all the other little worlds in it, seems lost to sight.

The day when the "naturalist" could know the details of all subjects is past, but the necessity of seeing the larger field is not less. Many of the major advances in science come through vision

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of relationship among regions of research which appear widely separated, and yet are connected in a very real sense. So atomic physics of the laboratory has proved to be one of the most important tools in study of the stars. In another direction there can scarcely be a wider gap in nature than that between astrophysics and problems of biological inheritance. And yet a singularly important question is presented by possibilities of influence from cosmic rays, assumed to arise in interstellar space, upon development and variation of certain elements in the living cell.

Some of the greatest discoveries arise through association of persons engaged in study of widely separated subjects, but each sufficiently broad-minded to consider the relation of his work to that of others. Such advance depends in a measure upon experience or training in fields of breadth adequate to open a vision of the larger picture.

Appreciation of the need for considering each problem of nature in the light of its relation to the larger scheme of things may come from contact with any situation in science or in everyday life. It is, however, possible for us to live long without having this revelation of unity as seen through continuity in operation of natural law in time or space.

Perhaps the earliest expression of this view of unity appeared in the idea of one God in Nature, instead of many warring deities. Certainly there has been no greater stride in human thinking than that which extended to the universe the type of coherence that modern science reflects in the law of gravity, or in the marvelously rigid adherence to rules of movement in light.

But the world of thought is not a level plain. In it there are mountain peaks and valleys, and a sudden view over wide fields sometimes gives a startling vision. So with respect to interrelation of the elements of nature, there are places where the picture reveals with exceptional clearness the idea of continuity in law and interdependence of the features involved.

If one were to take the instant wings of thought and flash through the universe of space and time and movement, it is doubtful whether within the range of these wide spaces there would be found another situation presenting as much of continuity through time and action as is seen in the cinema of earth history at the Grand Canyon. There may be other places on this earth that are

comparable. If so, they are few. We have no assurance that close similarity to this particular type of relationship will be discovered elsewhere in the universe. I have chosen to turn attention to this concrete thing which touches both our intellectual and our spiritual life. I look upon it as a treasure house of science—an immeasurable influence upon human thinking and ideals.

In this age of experiment we have established the idea that observation of a process is more important than speculation or calculation. The assumed laws or modes of procedure upon which we base calculation may be inexact. If so, the results will express this inadequacy. Experiment is only experience in a measure under guidance or control.

History, whether relating to man or civilization, or to the earth, or to astronomy, is a record of experience. Time and the relative position of events in it represent one way of describing the occurrences. This expression of experience indicates in some measure the laws which have governed action.

To-day the world stands at attention when the astronomer stops in his task to tell us of the history or evolution of worlds, of planetary systems, or of spiral nebulae. Also, regardless of any preconceived notions, all mankind watches with intense interest whatever comes from investigations on the history of man's long-extended striving to better his position and to deepen his knowledge.

But nowhere in the universe of stars, nor in human experience, nor in any other phase of history, do we visualize in a manner more striking than that at the Grand Canyon the presence of moving events of history, with the reality and order of occurrence so visualized that one sees, as it were, the whole panorama in action.

Astronomical measures of space and time reach to figures that we fail to comprehend. We are staggered by the statement that light moving at its terrific pace would require one hundred to two hundred millions of years for passage from some of the more remote spiral nebulae to the earth. In looking out over space, the universe as we see it in different places actually represents different geological ages perceived at the same moment. At the Grand Canyon a vastly longer series of ages, or of different times, is visualized at the same moment and in the same place. The events in the Grand Canyon story are, moreover, presented in such manner as to express continuity of action extending through them.

Outside the field of geology, I am not aware of any actual measure of events in the universe, even remotely related to observation, which involves more than approximately two hundred million years. The story of the Grand Canyon, as seen in a casual glance, gives us, according to the geologist, a reasonable assurance of considerably more than one thousand million years.

The geologist divides his story of the earth into the astronomical period and the strictly geological. For the first he depends upon the astronomer. There is no observatorial record of this part of the past.

The strictly geological record based upon actual relics which we may examine divides itself into three parts: first, an early or Archeozoic, in which the record is heavily defaced by influences that have almost completely changed the remaining materials. No traces of life are found in this rock system.

A second period, or the Proterozoic, is represented by a vast thickness of layers formed upon the earth's surface by processes much like those in operation to-day. From these rocks, resembling mud, sand and gravel of to-day, we have rare remains of life foreshadowing that of the present.

The third division of time, approximating in length the second, includes most of the great formations we meet generally over the world—tens upon tens of thousands of feet of strata, like deposits of to-day, and containing abundant remains of plants and animals.

In a single glance at the walls of the Grand Canyon these three divisions of time are all clearly represented together.

The Archean or the oldest rocks here shown are the torn and mangled remains from an earth of so long ago that almost have the elements destroyed it. The mass was buried at times beneath so deep a load of sediment that it barely escaped complete alteration of every physical character. It was filled with materials that crept into interstices of its shattered body. It was squeezed into mountains and again lifted high till erosive forces in large part wore it away. What we have left represents time and antiquity as does perhaps nothing else that we may find in the universe.

The twelve thousand feet or more of strata of the second great series, beginning at the bottom as it does with masses of rolled pebbles, including fragments of rocks from the first or earliest division, presents a picture of conditions not materially different

from those on gravel bars of the Colorado River near at hand. With all their hundreds of millions of years of antiquity, it was on an earth as of yesterday that these deposits formed.

To the casual observer, this story of time in the canyon walls may appear broken by many gaps. But what might be called interruptions are only changes of scene. Where the rolled pebbles of the second great series rest upon the oldest rocks, they are mute evidences of an uplift during which mountains were formed and washed away—perhaps the greatest single story of the region.

The relation of this seeming eternity of action in the story of the canyon to the physical processes of which it is an expression involves questions which we answer only in part. The natural forces that produced these changes are of two kinds: first, those movements of the outer earth which have lifted the continents and mountains; secondly, the agencies which have moulded the uplifted masses into forms of the land.

Of the first element, the movements of the earth now up, now down, the canyon gives reality, though only partial explanation. But we are not ashamed to say we do not know, at any rate when gravitation, constituting an important phase of the problem, remains itself one of the greatest mysteries of nature.

More easily visualized are the forces which have moulded the land. Often as one watches from the brink of the canyon, a cloud floating by is seen to lower a dark curtain of storm. In its path rain lashes the slopes, streamlets flow in the ravines, and mud-discolored waters begin their journey to the sea. This power that carves and wears the land, spreading the debris as record of its work, involves the wind that shepherds swiftly changing clouds, and all the features of the atmosphere.

No one who sees this picture at the canyon fails to realize that as the cloud which shapes itself and vanishes, so runs the story of the land. The rocks we see are only fragments that remain from great formations of ancient time. They bridge the short span of eternity which lies immediately behind us.

It is not possible to consider the geological story excepting in terms of the physical forces involved. It is also true that the nature of these elements is in considerable measure interpreted by the way in which they have operated geologically. In a sense the two problems become one.

To what extent the sources of physical power concerned lie outside this earth is at the moment a question for discussion. Some hold that if not as a cause, at least as occasion, the effect of radiation from the sun, along with gravitational influences, may have bearing upon movements of the earth's crust. The agencies which lifted the bulk of the great plateau high above the sea may, with participation of gravity, have involved light, heat and electric activity, which also give life to the winds and clouds.

The varied features of the scene are in reality one picture, from clouds to forming of the canyon; from the veil of beauty flung over it by shifting light to the immeasurable power that raised and bent the mountains' mass. Whether it be scientist or only one who comes to glory in the work of nature, the value of every part in it is most highly dignified when seen against the background of an interlocking group of elements, each most fully interpretable when considered in its relation to the others.

The Canyon has long been a superlative spectacle without reference to any direct relation it might have to the origin or becoming of life. To-day we see it not only as a place of great physical wonders, but as presenting, embedded in its story, one of the most thrilling accounts of the adventure of life through the ages. As yet this story is largely unknown, waiting for those who will come to chart these wildernesses of the past.

The record of life begins in the lower strata of the second series, the Proterozoic. It leads on up to the highest level of the walls. Then out across the Painted Desert and into the highlands to the north the story continues in still later strata. The multitudes of animals that favored the sea left their skeletons in myriads. Creatures that came out upon the land marked prints of their fingers in numberless thousands on sands of long ago which now form a part of the canyon walls. Dinosaurs pressed their feet into the soft surface, and the traces remained until we could come and wonder. And so into these millions of years of earth building the story of life is woven.

The intertwining of these threads of coming life with those of earth evolution we do not fully understand. The relation is at the same time the greatest mystery and the greatest challenge of the region.

In the presence of such overwhelming physical features as those

of the Canyon the living things of to-day that clothe the gentler slopes, or mantle the floor and the plateau above, may seem to have no greater importance than what we have known abundantly elsewhere. But they are of great significance in the larger story of the place, even if it is viewed mainly as a physical picture. In relation to study of the history of life, they express in striking manner some of the most interesting factors involved in the long record of living things entombed in the walls.

As illustrating the idea of interdependence of elements in nature, the garment of life spread over the canyon is an outstanding feature of this great spectacle.

In order that comment regarding significance of the life of the region to-day may be presented through concrete example, I have chosen to view the situation by way of a single incident. Riding through the forests of the North Rim on a recent journey to the Canyon, I saw a flash of black and white. The ranger said it was a "Kaibab squirrel, an animal peculiar to this area." In the branches of a yellow pine we saw him well—a striking figure with tasseled ears and a plump, dark body contrasted with a long white tail. His closest relative, the Abert squirrel, was said to be at home in the same type of forest on the opposite margin of the canyon. Only the gorge of the Colorado separates the areas in which they pasture. But never does either member of the family cross the gulf.

No one who sees these two closely related but strikingly different creatures, and learns that they live in areas separated only by the canyon, fails to ask how it happens that the boundaries of their range can almost touch without overlapping or mixing of the types. Is it chance that they resemble each other so nearly and are at the same time geographically so close? Did the two species migrate from distant regions to encounter this impassable barrier that prevented their knowing each that the other is there at the nearest point across the way? Or were the squirrels here before the canyon formed, or at least before it developed as a sharply separating chasm?

That two animals, each of all kinds in the world most like the other, should journey to a region where they would be separated by such a barrier is possible, but only as a remote chance. That the ancestors of these squirrels were there before the gorge took its present form, and through this separation were divided into groups

that gradually came to differ, appears reasonable under certain conditions. It would seem necessary to assume relatively recent development of the canyon, and also that variation in characters comparable to what is illustrated in these types has actually taken place in the past.

In examining the story of these two species it is important to note that not alone do the "Kaibab" and "Abert" squirrels show this interesting distribution in areas separated by the canyon. Associated with them, and separated geographically in precisely the same way, are types of spruce squirrel, chipmunk, ground squirrel and porcupine, along with others.

Concerning the first assumption, touching barriers to migration, it might seem that the canyon has little significance as a bar to movement of plants and animals. Deep as it is, many lateral extensions of the gorge give entrance to its floor. So far as means of travel are concerned, there is abundant opportunity for animals of all types and sizes to reach the lowest level and climb the opposite bank. The torrential river is a hindrance, but many creatures could find their way over it by swimming. Others would be washed across on rafts of debris in periods of flood.

But when the trained zoologist makes his census of life in the canyon according to location, he discovers that many animals competent to move freely up and down or across do not take advantage of this possibility. A map of the whole fauna and flora shows distribution corresponding largely to altitude and to physical and climatic conditions along the walls. In general, only the species of winged animals such as birds and bats extend across the gorge.

The range of climate along the canyon shows the floor to be approximately twenty degrees warmer than the South Rim. In winter, one leaves snow above to pass down through spring into summer. In summer you leave cool nights at the rim to find a zone of tropics below. Standing on the South Rim and looking into the valley of Bright Angel Creek, at the bottom of the gorge, there is seen a region of mesquite, acacia and cactus with environment of the desert. Looking across to the highest land of the North Rim, you discover an area clothed with beauty of pine, spruce and aspen forests. Each zone of altitude has its peculiar conditions of temperature and of plant and animal life.

How these belts of physical condition developed and how they

came to have each its peculiar life complement are questions involved in the inquiry whether the canyon and its climatic conditions always existed as we see them to-day.

Some part of the answer as to history of the gorge appears in the fact that the strata in which the canyon is cut are in considerable part deposits such as form only on the floor of the ocean. The upper layer in the walls is composed largely of remains from sea animals. Included are corals and the teeth of sharks. The present position of this limestone, at 7,000 feet above the sea on the South Rim, ranging to 9,000 on the north side, and several thousand feet lower at the town of Kanab to the north of the Kaibab plateau, indicates an immense change of position through uplift and warping.

While this movement of the strata was taking place, or subsequent to it, the stream cut its way across the mass. The possibility of zones of physical condition developed as the region was being lifted. To-day the rocks of this area fill more than two-thirds of the habitable space in the atmosphere between sea-level and the zone of an arctic climate at 10,000 to 12,000 feet elevation. These belts of climate were, so to speak, exposed by the river as it cut its way.

Whether or no the squirrels were there before the canyon was excavated, there was a time when these climatic zones, with their possibilities of varying life, had not been developed. If the squirrels had been present in the region at any level of altitude before the canyon was formed, gradually they would have found themselves separated into two groups in areas divided by barriers unfavorable to intermigration. Or if great climatic changes occurred in the course of cutting the canyon the squirrels have shifted their habitat until they are now divided by a gulf of climatic differences corresponding to the magnitude of the chasm.

The second assumption which seems a requirement, if we are to believe that present distribution and differences of the two types of squirrels are related to physical modification of the region, concerned evidence that animals have in the past changed to the extent of difference between these species. This question we may not answer fully by evidence at the Canyon, but most suggestive data are presented.

In the same landscape which shows us such striking illustration of adjustment in present-day life associations to changing topographic and climatic conditions, we see a tremendous spectacle of life as it

was modified through the geological ages. This record of the rocks presents proof of abundant life through a vast period, in which the kinds changed many times, and tended gradually to approach types living to-day. The strata in which these remains of animals and plants are buried give evidence that the physical conditions constituting the environment of life varied markedly through geological time. In a manner keeping pace with these modifications in the physical world, the living things changed also.

So in viewing the story of variation and distribution of the tree squirrels in the North Rim and South Rim areas, one comes always to the idea that the account is most logical when seen as an expression of many interrelated factors. There appear to be included the influence of physical changes which we understand only in part, and of biological laws concerning which our knowledge may be even less clearly adequate.

The more closely one studies the time panorama of the Canyon area, the more numerous are the problems raised regarding history of the relation between life of the region and its environment. Among the factors presented we can not avoid recognizing the connection between development of existing zones of life spread upon the walls and the physical changes that produced the gorge. Whether or no this relation indicates direct influence of these developing physical conditions upon the different life associations by which they are inhabited, they at least illustrate an adapting of groups of living things to physical conditions as they varied. In the same way it is difficult to understand the close relationship of species so clearly held apart by sharp geographic separation, without assuming that topographic and climatic changes are among the important factors concerned.

The present status of scientific knowledge does not afford us evidence of experimental type indicating the manner in which the suggested relation between physical environment, varying through time, and changing biological characters has developed. We are at the moment in a stage at which we know that we can not dispense with an environment, and yet do not know precisely what the influence of surrounding conditions may have been. But certain it is that no one can stand before this scene without being conscious of the fact that life as we see it in the landscape to-day mirrors the past and its changes. The unity of nature so strikingly illustrated

by intimate relationship between physical factors in this story is no less clearly expressed through linking of biological features to each other, or to development of the physical world in and through which life has grown.

We have seen a picture of the Canyon as visualized by the scientist. But the deep impression which evidence of unity in operation of the forces involved makes upon the investigator may not be more important than that in the case of students of nature concerned only with what is sometimes called the human point of view.

In some respects it is difficult to distinguish the phases of thinking defined as scientific from those known as esthetic or spiritual. The stimulus which drives a great constructive worker in science may separate itself only slightly from that influence leading the master in art or literature to what he considers his mission.

The scientist takes the impression he has received from nature as the starting point for an adventure in securing and interpreting facts. The ultimate result of his effort depends partly upon fidelity to the work of obtaining a knowledge of reality, and partly upon ideals relative to significance of the facts when brought into relation to others.

The great artist or the writer does not set for himself merely the task of describing form and feature of the thing he sees. He attempts to make clear also their meaning to him as an individual human being. In proportion to the extent to which his painting of reality is inaccurate he fails. But he fails completely if his interpretation does not present a true expression of its influence upon him, or its meaning to human kind as typified in his personal understanding or feelings.

It has been stated that nowhere more clearly than at the Grand Canyon does evidence of interrelation in elements and unity of action impress itself upon scientist or investigator. Through such visualization of nature seen as a whole we come often to realization that, even when enlarged by the lens of knowledge, the picture indicates the presence of something beyond that vision does not fully reach. So, in various other ways, artist and writer have presented the idea that, in looking upon these great examples of unity in nature, what we see may be only the shadowy expression of things greater still, which neither eye nor mind has yet been able to define.

THE TREE IN THE ARCHITECTURE OF WASHINGTON

Known over the world for high attainment in planning of its man-made structures, Washington is recognized also as a city in which the architecture of nature is given exceptional importance through varying expression in uses of the tree. Sometimes these living columns set off features of imposing buildings. Again as spires they direct attention to a changing sky. Often they span the street in arches such as man has long striven to copy in his most inspiring edifices. Widely through the city these domesticated forests are controlling elements in the forming of vistas which give to human achievement in building much of its charm.

In large measure the attractive natural parks of Washington are dominated by trees extending the quiet of a wilderness into the city's midst. So effective is this penetration that sometimes within a few seconds one may go from noise of crowded traffic into shadows of a wood, where only damped sounds of pounding wheels serve to remind of the mechanical hurry in present-day civilization.

Although, like organic beings, cities commonly grow without conscious direction, they must always meet certain needs of intensified use both as habitations and as opportunities for organized business. Special purposes of Washington make it the center of administration for a nation having extremely diversified interests, all of which are involved in the effort to organize a government by will of the people. Fortunately the general structure of this particular city has been the subject of careful planning with reference to present and future needs.

In considering the architecture of a city it is important to keep in mind that an organized unit of this type does not consist merely of streets and houses. It represents the collective features related to life and work, to maintenance of existence, to effectiveness of business, and to enjoyment of living by those for whom it may be either home or only a place of temporary occupation.

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Just as a forest is not merely the ground upon which trees stand, but involves the composition, bulk, and movement of air blowing over it, the sunlight promoting its life process, the multitude of plants and animals surrounding it, and the bacteria which mould constituents of its environment, so a city is not solely ground or buildings. It comprises all the elements that contribute to make it a place in which human living can be conducted effectively with health, comfort, and well being. So Washington is not simply an areal plan or a group of inanimate buildings. It includes all that aids in development of its mechanism and function designed for a great national purpose.

Situated midway on the Atlantic Coast, the climate of Washington presents conditions intermediate in range of the whole country. In this situation use of trees may represent overlapping aspects of vegetation for much of America. It is essential that there be dense shade in summer, and that the blanket of verdure which shuts off heat and light in brilliant days of the middle year be removed to give comfort of the sun's rays in winter. So, in planning the city its walks have been bordered by trees losing their leaves in the colder season, while the groves for use as quiet retreats in warmer portions of the year are largely made up of woods which give a maximum of light and sky in December.

Special planting of trees has not contributed alone to comfort in summer and winter. By giving changing vistas and contrasts through the cycle of the year, it has also added an important element of variation to the program of city building. Street trees and groves range in beauty through the seasons from leafless branches against winter skies to the charm of opening buds in spring, the heavy green of summer, and the brilliant foliage of autumn. All that is expressed by the trees in their own right is also a contribution to contrast with architecture of buildings which are simple and beautiful, and yet sometimes cold and formal.

In the scheme of humanly-designed structures the varying perspective due to presence of trees contributes much. And to the three dimensions of space, there is added a fourth element represented by changing foliage of the advancing year. Tinging it all is living color shifting with seasons and with lights and shadows of the day.

The wider spaces designed for breathing or recreation, and for

stimulation by touch with natural beauty, represent an achievement of special importance in which opportunity for friendship with trees is one of the larger values. The quick shift from pressure of traffic and business to the relaxing influence of contact with the out-of-doors is a factor of real significance in the plan of this city.

So it is, for example, that where Columbia Road, Eighteenth Street, and Adams Mill Road diverge, the length of one block separates a business cross-road from an elm-bordered avenue swinging suddenly down to the Zoological Park. Car lines and automobiles converge and diverge under guidance of automatic signals. Yellow caution lights perch alongside stations of safety for those foot passengers whose fraction-of-a-second dash does not permit a complete journey across the traffic stream. Two blocks distant the grateful shade of a quiet grove brings the peace of nature.

Passing down the road, the comfort of at least semi-solitude envelops one. The clank-clank, tlat-tlat of passing street cars is still audible, but as if from an outside world. Especially at this place rises the memory of Longfellow's sonnet concerning restful seclusion of such a retreat, in his contrast of a busy street with the quiet of a cathedral:—"So, as I enter here from day to day, and leave my burden at this minster gate, . . . the tumult of the time disconsolate to inarticulate murmurs dies away, . . ."

The comfort of the wood below seems not wholly due to absence of sound. Though trees do not talk back, and therefore never appear to be misunderstood, they express their own qualities in addition to what we attribute to them. While at times they may appear dull and lifeless, commonly they embody the joy of living.

The beech trees which favor this road have an architecture which sometimes appears to lack plan and unity distinctive of their associates, the tulip trees. Again they may be tall, straight and slender, and in their mass show marked symmetry. The beauty seems not to be produced by one swift stroke, but is rather the result of cumulative effort.

Although reaching always toward the sun, the beeches do not each time take the straightest path. Sometimes they sprawl in trunk and roots as if attempting to keep near the surface of the soil, and their graceful branches droop over the ground like wings of a mother bird.

The stem of the beech is sturdy, establishing its strength in a

great pillar. In external modelling, the buttresses appear like huge muscles seen through a closely fitting skin. Contrasts of light and shade and color are accentuated by smoothness of the bark and often one sees sharply pencilled shadows of delicate twigs marking their clear outlines on the whiteness of the trunk.

The grove through which one passes on the slope where the road leads down to Rock Creek can have a somberness approaching gloom when the trees are soaked in rain. Or in light of a gray day the trunks almost fade into mist. In bright, clear atmosphere the stems and branches have a tint of silver. The beauty of the place leaves on many so deep an impression that it remains in memory as "the silver forest."

The architecture of these trees fits itself to varying moods of seasons. Each period has its charm differing widely from that of other stages. We may dislike cold and rain, and be weighed down in spirit by bare, leafless poles of December woods. Yet for some who look through such a mass of naked branches there is consciousness of enhanced beauty in the sky beyond.

Fall, commonly considered the season of melancholy, is perhaps the time of greatest splendor in the groves, the period of fruition, the stage of flaming glory of maturity. Flowers of spring and summer are replaced by the most gorgeous raiment of the year. Ships go down with colors flying. Forests greet approaching twilight arrayed in their most splendid garments.

No city has offered opportunity for development of a plan in which greater contribution to comfort and beauty could be made by use of the tree than is now possible in Washington. Experience of the last half century brings out the nature of the problem, the many values of the tree in present living, the needs for the future. There has never been a situation in which the elements for contribution to understanding of a question of this nature were more fully represented or better organized than is true in Washington today, with our great government departments engaged in study of forest problems, and with discussion of city planning continuously active.

There is a special challenge in the opportunity offered for increase of contribution by the tree toward evolution of the architectural scheme and betterment of living conditions in Washington of the future. It is desirable that all elements involved be centered in

development of this peculiar interest. There should be included every related phase of government in the city, the resources of all federal activities which touch this special problem, the specific opportunity for experimentation by the Forest Service and the National Arboretum, and the contribution of many non-governmental activities located here.

The influence of such a work would not be reflected alone in adding to comfort of living for the many who make this a place of residence. It would show its value as well in bettered conditions for constructive work of those who study federal policies as they concern the nation of the future.

SCIENCE AND CITY TREES

Although modern city life requires such intensive occupation of land as almost to eliminate natural features, we still hold to the idea that growing things constitute an essential part of our environment. Just as we see special value in features of primitive nature which were once considered obstacles in the path of progress, so, now that the tree and other living things have been pushed to outer limits of the city, we come to recognize their importance.

The fact that today we long for the freedom of outdoor life, and appreciate more than ever the unmodified beauties of nature, does not mean that forthwith we shall give up advantages of civilization and return to savagery. Neither does loss of the tree from crowded portions of the city mean that in order to find a continuing place for trees we shall relinquish anything of real significance acquired in development of the great metropolis.

Centuries ago, growth of cities resulted in narrowing the space for traffic until many streets became alleys. Modern transportation and increasing height of certain structures has permitted widening city limits, allowing more space for dwellings in the peripheral portion, and at the same time broadening streets is permitted, giving increased air-space in the central region.

Engineering development in cities has tended to eliminate contact with soil, dust, and mud by clothing the ground with concrete or asphalt. Such planting as remains has in large part established its relation to mother earth through relatively small perforations in pavements. The result has been reduction in possibilities for maintenance of existing trees and increasing difficulty in cultivation of new plantings. The question has naturally arisen whether in the perfected city, protected from contaminating soil, the beauty of foliage and grateful shade of the tree can have an important place.

Although we have abundant information regarding evolution

American Civic Annual, vol. 4, pp. 205–207, 1932.

of engineering methods in city-building, we are not yet sufficiently acquainted with the growth-process of trees to know fully the relations of living plants to light, heat, and elements of the atmosphere in a city; nor have we more than the beginnings of knowledge concerning requirements of the root-system and how it accommodates itself to the soil so largely covered by pavements. With all of the advance in study of vegetable growth, we are still far from having a knowledge of operation in the plant mechanism corresponding to our acquaintance with the steps by which flow of gasoline into the engine of an automobile can produce combustion, transmuting itself into power applied in locomotion.

The mechanism of a tree must be recognized as a vastly delicate and beautifully balanced organization. Science has given us a partial understanding of what takes place in its functioning, but the thing which we call life, represented in growth and development, is still among the greater mysteries. We must realize further that even when we determine the general processes of life and growth in a tree, there will still remain need for knowledge of the vast range of differences in which this mode of operation expresses itself in the multitude of types of trees with their variety of foliage, trunk, and root. Classification of plants has of necessity limited itself in large measure to study of flowers, leaves, and general structure. There is still a large, unexplored field in the comparison of physiological processes of trees.

When one approaches the problem of adaptation of the tree to changing conditions of the city there is faced, among numerous problems, the lack of information as to what the tree does and how it accommodates itself, and secondly, the need for information as to how different types adjust themselves to varying conditions.

In addition to need for investigating habits of the tree, it would be important to know in as practical a way as possible the story of what has happened to trees through their direct relation to engineering development of a city, such as Washington, noted for its trees. Full records will tell precisely what has happened in engineering development, and when it happened. It is possible to learn the story of pavement, sidewalk, and the multitude of structures in the form of sewers, gas-pipes, and conduits for electric wiring of various types which lie beneath the streets.

Fortunately, there is also available in every tree a record of its

history. As the trunk forms, layers of wood build out around the stem. The accumulation for each year is generally clearly defined in contrast to that of the years preceding and following. Various conditions, such as moisture, heat, and light, which affect the growth of the tree are recorded in the wood. Favorable conditions accelerate growth; unfavorable ones retard it. This change of pace may be recorded in thickness of the rings of wood or in nature of the cells produced. Extension of any engineering feature in such manner as to influence the growth disadvantageously is recorded in the tree.

To read the record of changing conditions in trees may be a difficult task, but science sets itself to obtain the solution of many problems, the answers to which seem at first beyond reach. The microscope and innumerable devices for measuring minute quantities have contributed to practical everyday life much which once seemed beyond the range of human ability. In an effort to learn what has happened in the history of trees in a city we would have both the record within the tree-trunk and the precise account of engineering operations. There could also be obtained from near-by yards the records of trees which were not influenced by engineering work. Taken together, these sources of information should give us a story of tree-growth as influenced by city development.

Much has been done in study of how the tree can maintain and improve its place in the city. In addition to the large volume of data available, we may expect further contribution to fundamental knowledge of plant-growth, its variation in different types, and concerning the history of what has happened to trees in city building. On the basis of such data, we may expect to formulate plans by which the tree will keep its close association with places of human habitation.

EDUCATIONAL VALUES OF RECREATION

Mr Chairman, ladies, and gentlemen, I have a little fear that in the enthusiasm for subjects which furnish my recreation I may be imposing upon you a discussion of something with which you are already more familiar than I.

There has been much written on the educational value of play, both as concerns the child and the grown-up. The contribution which I have been making to my own thinking relates more largely to development of the adult.

In any discussion it is important to give definition of the things with which one deals. It is then possible to judge one's purpose. I look upon recreation as largely concerning itself with rest or change of occupation in the therapeutic sense, or with activities which have to do with the building-up process, whether it be physical, mental, or spiritual. Much which we class as recreation is in large measure attempt at self-expression. Most of the people in the world spend the greater part of their time in making a living, and only in so-called recreation do they find opportunity for activities which are wholly satisfactory to them.

Education I should not attempt to define more than to say that to me it is a process by which we learn first of all what our capacities are, and what we may attempt hopefully. We assemble a few facts with which to work; we measure ourselves against problems of the community; we learn self-restraint; and we attempt to see that the candle of our lives is somehow lighted with that inspirational thing which we call interest.

A small part of the time devoted to education may profitably be used in study of self-control. As a small boy, living in contact with Indians, I thought it a great thing to learn. When the town became large enough to support a band, I trained myself to sit reading a book with my back to the window without showing evidence of interest, while the band went by. This is useful, but

Address before the annual meeting of the American Council on Education, Washington, May 7, 1932. *Educational Record*, vol. 13, no. 4, pp. 253–256, October 1932.

I do not believe that anyone has accomplished much in the world's work merely by self-control. In last analysis, it is stimulus of interest that gives the greatest opportunity in life, and then self-control becomes important.

Consider the difference between a child sitting in a schoolroom on a warm spring morning at about eleven-thirty, plodding away at algebra, Latin, or some other largely foreign thing; and then see the child a half hour later working himself to the limit physically and intellectually in our great American game of baseball. In the schoolroom he had reached his limit, couldn't do another thing; on the playground he is an active, vigorous creature stimulated by the enthusiasm of a personal interest.

I know that many of you have studied what to do with the child in order to bring into the educational program the kind of interest shown outside the schoolroom. It is not my purpose to suggest how we might change the educational program for the child so as to profit by advantages in the educational use of his recreation. You have done that in many ways. I ought, then, at once to turn attention to the other aspect of the problem, namely, the educational value of recreation as it relates to the adult.

I sometimes think of education with a definition different from that given a few moments ago; that is, as representing the continuing intellectual and spiritual growth of the individual. I look upon life as a process which stops when growth ends. When our mental sutures close there is no particular interest in living, and we cannot be particularly valuable to others.

Looking upon recreation as a process by which we may shift to some other activity in order to build up physically or intellectually or spiritually, I see it, especially for the adult, as an opportunity for that kind of expression which concerns our deeper personal interests.

One of the contacts which I have enjoyed in the past few years has been through relation to educational work as it touches outdoor life in various activities, such as national parks, state parks, and city parks. In the course of this experience I learned that the man or woman who goes to Grand Canyon or Yellowstone or Yosemite for a week's vacation is cut off, for the moment, from the business of making a living. Nearly all of the small cares that make up a good part of our ordinary living are also left behind.

Under such conditions the mental and spiritual processes turn not only toward appreciation of nature, but toward enjoyment of intellectual life. Frequently, at such times, consideration is given to the greatest of our problems. The most intimate and deepest spiritual experiences may develop and great decisions be made.

The spiritual process under these conditions is not just separated from life. It is based upon previous experience, and is a summing up of elements which enter into our problems. It makes possible clean-cut decisions that are not turned this way or that by exigencies of the moment. I discovered many people forming opinions relating to the most critical of all questions, intellectual and spiritual.

A part of the function of national parks, as I see it, is to develop an environment in which this thinking may be carried on to best advantage. The situation concerns not only the natural features around us. It also involves opening opportunities for thought along lines which may be beneficial or constructive under these particular conditions.

In thinking over this problem a few days ago, I hesitated a moment as to the precise title of the discussion. On finding that it was "educational values of recreation," it occurred to me that it would be interesting to see what it would look like if stated as the "recreational values of education." It seemed to me that this situation offers a real problem.

When a man or woman goes into the open to be free from cares and to do thinking along the lines which are most important, you deal with the educational advantages of recreation. Why should we not carry back into the routine of everyday life the idea of having recreational joy from the things which are educational, instead of looking upon them as done in order to maintain our place in society?

Whatever comes out of this particular period in the history of the world will include the idea that, after all, things of the mind and spirit are relatively important; and that there is as much or more joy to be obtained from them than from the rush of other things which have seemed to represent the acme of development in American life during recent years.

I believe also that we are coming to a place where reasonably clear presentation of evidence, and an unbiased judgment, without

reference to money, will have value. I look back only a very short time to the period when some of my friends preached the idea that you couldn't have a great war because you couldn't finance it. When we came to the war, everybody laughed because we could have all the millions and billions wanted. We borrowed them from the next generation. Today we are wondering whether we really could afford it, after all.

It is only a few months back to the time when we all wondered whether, after all, bonds were worth much compared with stocks. I remember sitting with a friend, discussing whether United States Steel Common, one of the greatest potentialities of the country, was a good buy at 170. It went to 260, and they laughed and said, "Why, it's going to 360." I don't know what it is this morning—perhaps 26.

We have been stampeded by judgments that had to do with accumulation and organization. I hope we are coming back to a time when all can say what a friend remarked the other day, "Well, we've not lost anything but money; all the things that are worthwhile we still have."

If we could now develop the recreational advantages of education and make this a part of the joy in life, we could at one time talk about the educational advantages of recreation and at another time we could urge the recreational values of education, or of the higher life.

Carnegie Institution, Washington, D. C.

PARKS AS AN OPPORTUNITY AND RESPONSIBILITY OF THE STATES

THE creation of parks as a responsibility of States of the Union has intimate relation to the basic governmental function of the States. Attempt to attain real understanding of the State Park problem, or to work toward constructive programs for the future, can mean little unless considered with this aspect of the question in mind.

The opportunity of the States as contrasted with other aspects of governmental organization has consistently maintained a position of primary importance in our national thinking. Higher place has been given only to problems concerning personal liberty, and to certain essential principles which involve need for unity of action by all the people.

In elaboration of our executive, legislative, and judicial machinery, the Nation has steadfastly held in view the principle that Federal problems are limited to those which concern the welfare of the people as a whole and not any limited community. Of this type are the obvious requirements for immediate and unified control of relations of the country to other nations, or for military protection in emergencies not to be averted by statesmanship. Other questions demanding Federal attention concern issues seemingly of limited significance, but influencing ultimately the well-being of the whole Nation. Such may be groups of factors apparently local but involving our national relation to a foreign power, or what may appear in particular cases to be narrowly circumscribed developments of disease in reality endangering the health conditions of the entire country.

Present-day tendencies regarding desirability of liberty of action for individuals and groups is expressed unequivocally through study of business interests. Here we find the view that it is best to

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avoid bringing under centralized governmental direction, or even under legislative control, any activity which can arise and maintain itself under private auspices and achieve acceptance as serviceable to the community.

In the field of our fundamental convictions, as, for example, in religion and education, we have never varied from the view that there should be freedom of belief in accordance with wisdom and conscience. In education we have as a nation refrained from dictation, though always insisting upon truth as a guide. In science Federal governmental machinery has been used to help in solution of problems which could be met only by organization requiring concentration of community interests. So in agriculture, a field occupied by great numbers of individuals, with relatively small holdings and relatively limited opportunity for fundamental research, the Federal Government has set up comprehensive and highly organized investigational work in the Department of Agriculture. On the other hand, in industries such as those concerned with illumination or telephonic communication, which tend naturally to highly developed organizations competent to study their own problems, the Federal Government contributes less of its centralizing effort.

While, with each stage of advance in human organization, we see more fully the need of recognizing interdependence of individuals and groups, in general, modern government tends more and more to refer responsibilities back to the ultimate source of judgment, either in individuals or in groups with special common interests. This trend is concurrent with that emphasizing the need of education of the individual and of the group to full realization of responsibilities. The tendency through the ages is distinctly toward promotion of better understanding and acceptance of those principles which normally and naturally control human relations, rather than toward promulgation and enforcement of artificial measures or laws by centralized authority.

The doctrine of State Rights was never intended merely as an objection to restraint. The element of liberty involved was essentially an expression and acceptance of responsibility of the smaller group to live its own life to the limit of advantage consistent with maintenance of similar privileges for others.

There are in the United States today seven metropolitan regions

having each over 1,000,000 population, and a total of over 19,000,000. There are ten other metropolitan areas each with a population of over 500,000. To understand the significance of these figures in discussion of the problem of State governments, it should be noted that these great concentrations present very many elements of unity, and that there are seventeen States in the Union with a population of less than 1,000,000 each, and nine States which do not exceed 500,000 in population.

The result of this centering of population, of business organization, and of wealth, in cities naturally brings critical problems regarding limits of social opportunity and governmental control. Especially do such questions arise in consideration of relations between the larger cities and the States in which they are situated.

The relation between government of a great city and the State in which it is included is a question in the front rank of those urgently needing investigation. Whether in the future greater cities will be separated as units comparable to States, or whether it will be desirable to keep a balance between urban and non-urban types of population and of resources, is a problem worthy of most careful, constructive thought. The future of State government itself is one of our most important problems. There seems today a general drift away from centralization.

There is reason to believe that in discussion of the various questions concerning opportunities and responsibilities of the State, the problems raised through creation and maintenance of parks have comparatively clear answers with reference to relationship both to cities and to the Federal Government. There is, moreover, reason to believe that intensive study of these particular questions may give us light on the future function of the State.

It is of course possible to bring into discussion of the State Park problem many elements of uncertainty arising out of differences of opinion as to the ultimate purpose of park reservations. I believe, however, that even accepting the most comprehensive scheme of park functions, there is small possibility for critical difference of opinion or confusion concerning the nature of the responsibility of the State, or of the necessity of having organization such as the existing State governments function in furtherance of the general purposes of the larger park program.

Setting aside for the moment consideration of certain special func-

tions of parks as some may interpret them, there is general acceptance of parks as presenting opportunities for breathing spaces, for outdoor life with physical recreation and relaxation, for opening of the road to health, for widening of our opportunity for education, for promotion of contemplation or individual thought under favorable conditions, and for preserving sources of inspiration in great phenomena of Nature.

In their origin parks concern mainly attempts on the part of individuals, especially nobility or royalty, to eliminate the crowd for purely personal reasons. In recent time the cities, as among the principal promoters of park development, have recognized need for air and breathing space where crowding reached a stage of intensity no longer bearable. The result has been the appearance of gradually widening openings, in which the multitudes of city population have reasonable possibility for relaxation and renewed opportunity for enjoying the quiet of mind which comes through contemplation of nature.

The great initial work done by cities has extended itself into the educational field. This is expressed partly through presentation of Nature in its varied forms, and as nearly as possible with its pristine beauty. City parks have also made valuable contribution in the field of human relations through study of problems of play and of crowd psychology.

While parks of cities have naturally and properly enlarged themselves so as to bring freedom of outdoor life and even beauty of the wilderness into the city walls, there has been little tendency on the part of greater centers of population to control or develop the larger outlying areas now so important to us in consideration of park opportunities needed for the future of the country.

The purchase of certain small areas by various cities to serve as summer camps has raised the question whether cities will ultimately reach out to purchase and control the areas which their population might desire for vacation purposes. The problem will ultimately be discussed. The cities have, however, in general, based their programs for the larger recreational opportunities upon assumption that the Nation or the State will be initiator and organizer and controlling agency in providing against these needs.

While, then, the function and jurisdiction of government in city and State may have in many directions relatively wide overlap, the

zone between them is defined with reasonable clearness, so far as we are concerned with the problem of those larger park reservations required for guaranteeing the wider recreational opportunities needed by an increasing population. As between these two agencies, the responsibility evidently lies with the State to provide for its whole population, including the concentrations in great cities.

The contrast of responsibilities as between the States and Federal Government with relation to our needs for park areas is one in which the zone of nebulosity is wider than in comparison with the city. Yet there is no reason to believe that the ultimate definition of boundaries will be in doubt. There has never been question that the entrance of the Nation into the field of park development had as its essential purpose the dedication of certain areas illustrating expressions of natural phenomena of such exceptional type as to warrant their preservation for enjoyment and education of the whole people. It has never been assumed that the Federal Government would be expected to accept responsibility for providing that type of breathing space or recreation or education which has been so effectively developed through city parks. The kind of opportunity offered by National Parks is exemplified in the initial dedication of the great natural volcanic phenomena of the Yellowstone, the uniquely inspiring creation story of the Grand Canyon, or the majestic natural features of Yosemite.

The normal variation in human application of ideals may be expected to leave a zone of differing opinion relative to field and function of National Parks. But the trend of public opinion is toward support of the program already so splendidly developed by National Park Service.

Relation between functions of State and Federal Government in providing park systems seems to offer only slight possibility for confusion of issues or misunderstanding as to zones of responsibility or authority.

In another direction the responsibility of the State for park development relates to, and touches, the functions of Federal Government as expressed in the recreational use of our national forests. The large areas of non-agricultural land occupied by national forests represent a domain in which there is under way a great work in protection and use of forests considered primarily as an economic asset. It has been inevitable that other functions of the forest

develop along with the primary purposes relating to timber utilization. Such are the possibilities for grazing, the responsibility for watershed protection, and the exceptional opportunity for utilization of these wild regions for recreational purposes. It is natural that within the forest regions, defined in accordance with these broader uses, there be areas of exceptional beauty, attractive both for their recreational advantages and for their educational and inspirational influence.

In those States containing large areas of national forest the function of the State in promotion of park development is influenced by the fact that national forests provide wilderness lands adapting themselves in a most satisfactory way to recreational and educational purposes. It will no doubt be the continuing wise policy of the Forest Service to permit such use of these areas to the advantage of the public. It is also true that as time passes much of the territory will naturally and properly be brought into economic use. The recreational utilization may continue, but the primitive aspect of the areas will in considerable measure be changed.

Between the responsibility of the Forest Service for utilization of its economic asset for recreational purposes and the responsibility of the State to provide breathing spaces and recreational areas for its population, the line will be more and more carefully drawn with the passing years. It is important that we have clear understanding and recognition of such differences in function between State Park interests and national forests as will facilitate development of both programs with least waste of opportunity.

Reviewing the points of contact or overlap between jurisdiction of the State and of the Federal Government, it seems clear that when we recognize the character of the specifically national program of the National Parks, as representing the outstanding expressions of natural phenomena, and the basically economic function of the National Forests, there remains to the State an increasingly important responsibility to provide wide, permanent, and if possible primitive areas needed to guarantee the pleasures of outdoor life, physical exercise, relaxation, and enjoyment of nature. Through its parks the State should also care for many aspects of education. It may also properly furnish as its contribution toward the collective assets of the Nation many areas of natural features of limited or local extent which have national interest and value, but for which

the protection and control of the State can be developed more effectively and easily than would be possible for the Federal Government.

The future educational systems of all the States will undoubtedly furnish increasingly wide opportunities for intellectual and spiritual growth of adults. The broad field of Nature will be recognized as one of the major assets furnishing stimulus of contact with inspiring original materials which can teach their own lessons. A well-developed State Park system closely articulated to the educational program of the State may become one of the most important instruments for use in educational advancement in directions in which we have as yet scarcely examined the ground.

It has never been assumed that the Nation should pay the bills for swimming pools or ball fields or spaces merely for play. It has never been expected that the Nation would pay our bills for general education, even including those higher realms of knowledge represented by universities of the State. There is every reason why the States of the Union should care for their own community problems of recreation, relaxation, education, and in considerable measure for inspiration. Where central governments enter the field of paternalism to the extent of handling matters which can properly be cared for by local communities, not only does this develop a tendency to lean upon the Nation for things which can be provided through self-help, but there arises also the serious danger of interference or dictation by central authority in questions which should be settled on the basis of personal or local initiative. So in the case of parks.

As years pass the widening tide of population absorbs the open lands. Modern roads and transportation bring remote regions into easy reach. Just as cities waken to need for breathing spaces and the touch of Nature, so the whole country has roused to recognition of the necessity for plans, including not merely future preservation of abundant lands for outdoor life, but the guarantee also that within the boundaries of such areas primitive nature be protected and that its enjoyment be cultivated.

The cities through their parks and the Nation through its parks and forests have pointed the way. The States, first of all by reason of their local needs, see as their right and their responsibility the providing for present and future generations at a time when the work can be done effectively—a work that not done now may never

be possible. The States see also that not merely from local needs, but as a part of their contribution toward promotion of health, wealth, and spiritual development of the Nation, they have opportunity and duty to make provision for the future. The work must proceed upon a scale indicated by studies of increase of population and of the needs of a people that may not be considered physically and spiritually static. We are a race in which satisfaction and happiness will depend upon the opportunity to make real progress, and not merely to maintain the things which are.

Specifically in California, where a recent legislative program is being put into operation under wise guidance and most commendable management, we see a region exceptionally favored with natural advantages both of scenery and climate. The great cities here have already set high marks of excellence for park and outdoor privileges developed under their control. The Nation has given exceptional advantages through great National Parks and broadly spread national forests. In past decades enormous natural resources of importance to the public for park purposes have been available through courtesy of individuals and private interest. But it is clear that the freedom of a frontier State may not be expected to continue for all future generations.

There is reason to believe that in the present park program of California we have initiation of an enterprise second only to agriculture in its relation to welfare of the State as a whole. It is of surpassing significance in its relation to general physical and spiritual recreation of the State. It will become increasingly valuable for broader educational purposes, and will furnish a background for that development of science, culture, art and straight thinking which we all expect of this region.

PARKS: NATIONAL AND STATE

Preface

The two brief chapters of this paper have been brought together in response to request for a statement regarding function of National Parks and State Parks.

The first chapter, entitled "National Parks and Ideals of the Nation," was read before the National Conference on Outdoor Recreation on January 20, 1926, at Washington, D. C., under the title "The Responsibility of the Federal and State Governments for Recreation" and was printed subsequently in the Bulletin of the National Parks Association, Vol. 7, No. 49, March, 1926. This statement has been revised since the original printing.

The second article, on "Parks as Opportunity and Responsibility of the States," was read in more extended form under the title "Parks: An Opportunity and Responsibility of the State," before the Eighth National Conference on State Parks in June, 1928, at San Francisco, California, and was published in State Recreation, Vol. 2, No. 4, August, 1928.

Grateful acknowledgment is made to the National Parks Association and to the National Conference on State Parks for their courtesy in permitting separate publication of these articles.

Carnegie Institution of Washington
Washington, D. C.
December, 1932.

National Parks and Ideals of the Nation

Our National Parks developed in response to a desire for guarantee of continuing opportunity to enjoy natural features that command attention and interest of the whole people. The principles governing origin and growth of this system are in accord with those which guided in determining responsibilities of the Federal Govern-

19 pp. Privately printed, Washington, December 1932. See "The Responsibility of Federal and State Governments for Recreation," pp. 2165–2171, and "Parks as an Opportunity and Responsibility of the States," pp. 2248–2255 of this volume.

ment. Considered from the point of view of governmental organization, it has been recognized that, with increasing bulk and complication of machinery, it is not wise to centralize administration for aspects of nature that do not clearly require such handling. At the same time there has been appreciation of need for federal action in matters concerning regions and activities of importance to the whole nation, but for which adequate support and management can not be provided by other means. So National Parks have come into being to meet a national need.

When the wild places were available to everyone, attention was not drawn to the necessity of guarding our opportunity for contact with primitive nature. Now that population increases and the wilderness disappears, we come to consider provision for this feature of normal life which has had so great an influence in forming our ideas concerning political and spiritual freedom. Such needs for touch with nature as relate to the Nation are met by the Federal Government mainly through two agencies: National Forests and National Parks.

National Forests are administered with a view to making the maximum contribution through a wide variety of uses. Correlated with utilization of these great areas for purely economic purposes, there has developed a demand for their use as exceptionally favorable regions for enjoyment of outdoor life. This situation presents one of the most important means for meeting our extensive recreational requirements. Such opportunity in National Forests will doubtless be supplemented in time by similar handling of other large areas of publicly and privately owned forest.

National Parks protect for use of the people areas containing exceptionally impressive natural features. The typical parks maintain their primitive character unimpaired. The highest purposes of use and enjoyment have been prominent in definition of their function. Need of opportunity for undisturbed appreciation of nature has been recognized through fixing wide boundaries.

These parks have often been considered as designed essentially for physical recreation, and such use must be one important function. When the first national park was created, large spaces were available elsewhere for purely recreational purposes, but the region selected was characterized by natural features of exceptionally interesting or inspiring type. The recreational use for which these

parks may serve takes place under conditions peculiarly favorable to development of mind and spirit as well as of body. It is these higher values that have furnished the reason for special protection.

The ideal that has given the weekly day of rest so important a place in America has supported the better recreational phase of our life, not merely as a time to abstain from labor, or to secure physical exercise, but as offering also opportunity for spiritual reinvigoration. We are coming to learn that life is worse than useless if it does nothing more than connect a chain of circumstances permitting continued existence in the physical sense without mental or spiritual growth.

The shorter catechism states that man's chief end is to "Glorify God and to enjoy him forever." I always understood it to mean "enjoy *it* forever." In the State of Iowa, from which I came, we learned early that it is not the chief end of man to raise more corn to feed more hogs to make more bacon to feed more people to rear more children to plant more corn—or any other similar cycle; but that it is a part of man's normal life to appreciate as well as to use what he finds about him. The multitude of colleges in Iowa is evidence that this discovery was made.

National Parks have developed steadily in the direction of educational influence through use of the unsurpassed natural features which were the things that really brought about their creation. Having given more than forty years to study of special problems such as the parks interpret, I have some confidence in saying that for many purposes the purely educational value of these regions is beyond that of regularly established, formal educational institutions. Among the most important features are those which concern the nature of the earth, the manner of its building, the forces which have come into play, the meaning of the almost limitless history of earth-making as it is pictured.

In viewing nature, the Psalmist said, "The heavens declare the glory of God; and the firmament sheweth his handywork." What has been made presents itself in these parks in such manner that all begin to comprehend. Here is found also much that represents the unmodified primitive life of the world, remaining just as the Creator molded it over mountain and valley. Nature is said to be an open book for those who really wish to read, but there are grades and shades of meaning that may be hard to understand. There is

certainly no place where the leaves are spread more widely, or the print more clear, than in these portions of the book.

With all that has been done by geologists and other scientific men, by central administration of the Government, and by officials concerned with immediate administration of National Parks, we have only begun to convey the really great lessons to the multitude. Science itself needs to know more fully what the story is, and then simplification and clarification must help so to carry the great essentials over that the visitor may read, and may interpret without depending upon the word of another. To attain such clearness of expression is to stand upon the highest plane of education. For many objectives this level can nowhere be reached more easily than in the National Parks. For adult education concerning nature we have here the grandest products of creation presenting themselves as teachers.

The exceptional opportunities of these parks require support that will guarantee the most effective use. In such a super-university professors would be only guides and not instructors, but there should be a faculty chosen from leaders in thought and appreciation, a group of men who, standing in the vivid presence of the Creator, would serve to point out the road.

But the parks are not pictured adequately in the language of science as it is commonly known. In ways we have defined only imperfectly, they express elements of beauty and grandeur which lie beyond the realm of formally associated facts and logic. Partly does this attractiveness reside in that which stirs emotion through influence of æsthetic values; partly it is recognition of sublimity in the power and order behind nature.

I remember, some years ago, viewing the great mountain range at Glacier Park, thrilled with the living charm of forest and meadow and the cold brilliance of snow-field and glacier. But behind the splendor of this mantle over nature was clear revelation of the movement in creation—shown in the body of the range, which had been lifted and thrust forward many miles above the level of the plain. This act of building was the source of glory in the mountain. The overwhelming bulk and strength of cliff, with appeal of lake and glacier, represented only residual evidences of power exerted in this great work. And the garment lost nothing of its beauty through knowing of the majesty it clothed.

While National Parks serve in an important sense as recreation areas, their primary use extends far into that most fundamental education which concerns real appreciation of nature. Here beauty in its truest sense receives expression and exerts its influence along with recreation and formal education. To me the parks are not merely places to rest and exercise and learn. They are regions where one penetrates the veil to meet the realities of nature, and of the unfathomed power behind it.

I can not say what worship really is—nor am I sure that others will do better—but often in the parks, I remember Bryant's lines, "Ah, why should we, in the world's riper years, neglect God's ancient sanctuaries, and adore only among the crowd, and under roofs that our frail hands have raised?" National Parks are places in which reverence is a natural attitude, and where we turn inevitably toward contemplation of the greater things in life, and in the world about us. They are not objects to be worshipped, but they are shrines at which we may worship.

In contrast to the situation in National Forests, protection of National Parks is not supported by economic value. Today one of the questions of most critical importance in consideration of National Park policy concerns what is known as "complete conservation," or protection with all natural features unimpaired. In my judgment, not alone recreation as commonly interpreted—not even education in its routine aspect—can guarantee unbroken maintenance of primitive conditions in National Parks if great economic resources are involved, since both recreation and education can be made to operate along with economic use. But a function of such importance as to insure complete protection is, I believe, given in abundant measure through the higher educational and spiritual values, which offer the greatest and most noble uses to which any possession may be put.

The problem of preserving park areas must be viewed from every possible side. Each need should be examined, and final decision made in accordance with the most fundamental requirements. We should never hesitate to submit a good case for judgment. In recent study of possibilities for saving outstanding groves of redwood forest on the Pacific Coast, initial examination of the project found all the lands under discussion already in private ownership and marked for important economic operations. Consideration of

the higher uses for these groves brought about a situation in which the need for setting aside the finest regions was recognized, and the industries cooperated in working out a plan by which the desired areas could be protected.

The Federal Government we see, then, as responsible for preservation, in National Parks, of areas which are unequivocally of national importance, and for administration such as will guarantee continuing use of these parks for the high purposes through which they can give unique service.

Parks as Opportunity and Responsibility of the States

The principles involved in creation of State Parks have intimate relation to basic governmental functions of the States. Attempts to attain real understanding of the State Park problem, or to work toward a constructive program for the future, can mean little unless considered with this aspect of the question in mind.

The political opportunity of the States has consistently maintained a position of primary importance in our national thinking. Higher place has been given only to matters touching personal liberty and to the requirement for united action on questions that concern the entire people.

The result of centering population, business organization, and wealth in cities has naturally brought critical questions regarding limits of social opportunity and governmental control. Especially do such problems arise in consideration of relations between the larger cities and the states. The extent to which recreational opportunities offered by cities may overlap those furnished by states presents an interesting problem for the future.

While, naturally and properly, municipal parks have been enlarged so as to bring freedom of outdoor life and beauty of the wilderness into the city, there has been no extended program on the part of great centers of population to develop large outlying areas for recreational use. Municipalities have commonly based their plans relative to the wider recreational possibilities upon assumption that the Nation or the State will be organizer and controlling agency in meeting these needs.

Although jurisdiction of City and State may ultimately show overlap, the zone between the two seems well defined with reference to park reservations required for guaranteeing the larger recrea-

tional opportunities needed by an increasing population. Responsibility evidently lies with the State to provide these more extended areas for service to all of its citizens.

In contrasting responsibilities of the States for parks and recreation with those of the Federal Government, the zone of nebulosity is seen to be produced by factors quite different from those which divide functions of State and City. The types of opportunity offered by the Federal Government which most closely resemble activities of the State in development of parks and recreation are represented by National Parks and National Forests.

In evolution of our governmental machinery, the Nation has steadfastly held in view the principle that Federal responsibility should be limited to that which concerns welfare of the people as a whole; not that of any limited community. As physical recreation is largely a personal or local matter, it is not to be expected that the Nation would care for obligations of this type, except as they are involved in other functions that are distinctly of national rather than local scope.

It has never been assumed that, as a part of its special responsibility, the Federal Government would consider providing for the type of breathing space or recreation or education that has been developed so effectively through city parks. Nor is there reason why it should control activities which can be cared for by the States in handling problems of recreation, relaxation, and education. A State which assumes responsibility of this nature increases opportunity for joy of living. Where a central government enters the field of paternalism to the extent of supporting activities that can be cared for by local groups, it develops a tendency to lean upon the Nation for things which can be provided through self-help. There arises also the serious danger of interference or dictation by central authority in questions that should be settled on the basis of local initiative. So in the case of parks.

The kind of opportunity offered by National Parks we know to be exemplified in the initial dedication to public use of the great volcanic phenomena of the Yellowstone, the uniquely inspiring creation story of the Grand Canyon, and the majestic natural features of Yosemite. While normal variation in application of ideals may be expected to leave a zone of differing views relative to field and function of National Parks, the trend of public opinion seems clearly

toward support of the program as defined by the exceptional units through which the system was established. That such areas are guarded by the Federal Government does not mean that States should deny themselves the privilege of preserving and protecting whatever of unusual interest or beauty in nature they possess. Exceptional opportunities open to the States will often be regarded as presenting possibilities for increase in pleasure and profit to the citizens, as well as contribution of service to other States and to the Nation.

In another direction responsibility of the State for park development relates to, and touches, functions of the Federal Government in recreational use of National Forests. It was inevitable that many and varied uses of these forests would develop along with those concerning timber utilization. Such have been the possibilities for grazing, responsibility for water-shed protection, and the exceptional opportunity for recreation. Within the forest regions, defined in accordance with these broader functions, there are areas of unusual beauty, attractive for their recreational advantage, their educational value, and their inspiring influence.

In states containing large areas of National Forest the function of the State in promotion of park development may be influenced by the fact that these forest regions provide wilderness lands adapted to recreational and educational purposes. It will no doubt be the continuing wise policy of the Forest Service to encourage use of such areas to advantage of the public.

With passing years, the line will be drawn more and more carefully between the responsibility of National Forests for utilization of recreational opportunities and that of the State to provide breathing spaces and recreational areas for its population. It is important that we have such an understanding of difference in function between State Parks and National Forests as will facilitate development of both programs with minimum waste of opportunity.

It seems clear that outside the range of activities of the Federal Government there remains to the States an increasingly important responsibility to provide wide natural areas to be used in advancing the pleasures of outdoor life, physical exercise, relaxation, and enjoyment of nature. Through its parks, the State should also care for numerous aspects of education. In addition it may furnish properly, as its contribution toward the collective assets of the

Nation, many areas having national interest, but for which guardianship by the State can be developed more easily, and more effectively than by the Federal Government. Over the centuries, it may be found that pride in use and control of things of beauty by the communities in which they are located will give exceptional guaranty of protection.

Future educational systems of the States will undoubtedly offer increasing possibilities for intellectual and spiritual growth of adults. In this connection, the wide field of nature will be recognized as a major asset, furnishing inspiring original materials teaching their own lessons. A well-developed State Park system, closely articulated to the educational program of the State, may be an extremely important instrument for use in ways of which we are as yet scarcely aware.

As years pass the deepening tide of population blots out the open lands. Modern roads give easy access to regions once remote. Just as cities have awakened to need for breathing spaces and the touch of nature, so the States are aroused to recognition of the necessity for preservation of abundant areas to be used for outdoor life, and for guaranteeing protection and enjoyment of our natural environment.

The Cities through their parks and the Nation through its parks and forests have pointed the way. The States, first of all by reason of their own peculiar needs, see the making of provision for present and future generations as an opportunity and a responsibility at a time when the work can be done effectively—a work that not done now may never be possible. The States see also that, not alone for local requirements, but as a part of their contribution toward betterment in health and wealth, and advance of spiritual development in the Nation, they should aid in providing for the future. The work must proceed on a scale indicated by studies of population and of needs in a people that may not be considered physically and spiritually static. We know that satisfaction and happiness depend upon the possibility of real progress, and not merely on maintaining the things that are.

A BRIEF GUIDE TO THE PARAPET VIEWS, SINNOTT MEMORIAL, CRATER LAKE NATIONAL PARK

The views from the parapet of Sinnott Memorial, if observed in order as numbered, present a picture of great forces in the past which have helped to develop the beauty seen today. The story of Crater Lake on the following pages is copied from labels describing the views seen through the instruments.

ORIGIN OF THE MOUNTAIN

View 1

This Mountain Is Part of a Tremendous Series of Lava Flows

In late geological ages enormous flows of molten rock poured out over an area of more than 200,000 square miles, extending into Oregon, Washington, Montana, Idaho, Nevada, and California. These masses of lava came to the surface largely through great fissures in the earth. A typical section of such extensive flows is shown in the lava beds forming Columbia River Gorge.

Numerous volcanoes in this lava region represent relatively late outpourings of melted rock through small openings. They have contributed only an extremely small part to the total mass of lava. The mountain at Crater Lake is one of these volcanoes.

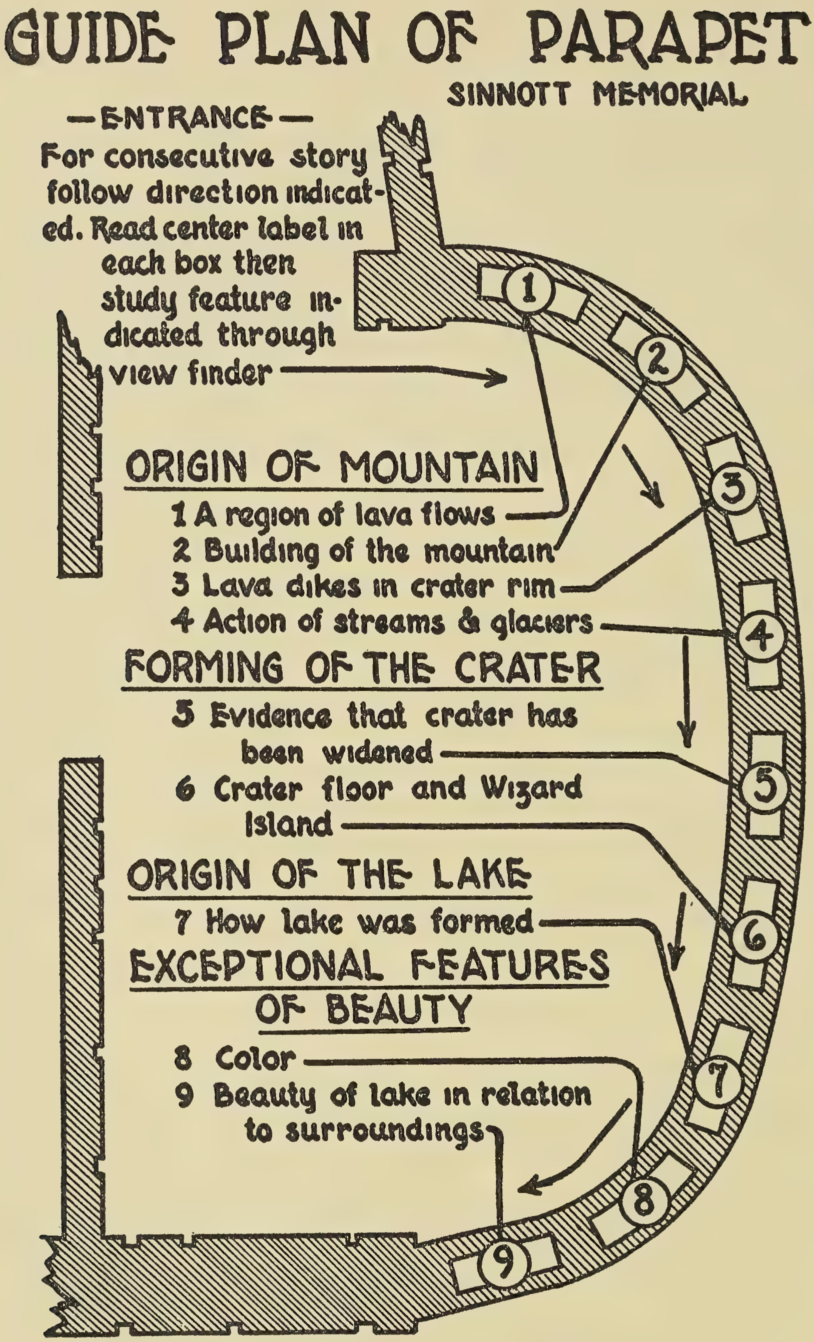
View 2

Building of the Mountain

The mountain in which Crater Lake rests was built by lava flows, poured out layer upon layer, and the piling up of volcanic ash, soil, deposits of streams flowing down the mountain, and materials carried by glaciers.

Two sections of the mountain are shown by finders to the right and left of this box. The one to the right is Dutton Cliff, made up of successive layers of lava and volcanic ash; the one to the left,

Leaflet prepared by a committee of the National Academy of Sciences and the Carnegie Institution of Washington as an aid to the visitor. 8 pp. Washington: Carnegie Institution of Washington, 1933.


GUIDE PLAN OF PARAPET
SINNOTT MEMORIAL
—ENTRANCE—
For consecutive story follow direction indicated. Read center label in each box then study feature indicated through view finder
ORIGIN OF MOUNTAIN
1 A region of lava flows
2 Building of the mountain
3 Lava dikes in crater rim
4 Action of streams & glaciers
FORMING OF THE CRATER
5 Evidence that crater has been widened
6 Crater floor and Wizard Island
ORIGIN OF THE LAKE
7 How lake was formed
EXCEPTIONAL FEATURES OF BEAUTY
8 Color
9 Beauty of lake in relation to surroundings
1
2
3
4
5
6
7
8
9

near Discovery Point, shows a series of layers consisting of lava, volcanic ash, and glacial deposits. Specimens of the rock from each of these sections are shown in this box. Both localities may be reached by trail.

One can understand Crater Lake in its relation to the volcano only when the mountain is considered as result of construction extending over a long period, in which many changes took place.

View 3

Lava Outpourings through Splitting of Crater Rim

In addition to spilling out as broad flows of melted rock, it is common for the tremendous mass of molten lava in a volcano to break through the mountain side. The lava filling of such a crack or fissure is known as a dike. After it cools the material filling these fissures is often harder than the surrounding rock. Subsequent wash of water may cut away the softer bordering material, leaving the hard filling of the fissure as a sharp ridge.

Devil's Backbone, seen through the finder at this box, is an illustration of a lava dike.

A diagram of the mountain in this box points out other radiating fissures or dikes. Specimens of these lavas are also shown.

View 4

Action of Streams and Glaciers on the Mountain in the Course of Its Building

In the section of layers forming the rim of the mountain there are evidences of wash by water. In some places this is shown by cutting of valleys; at others by accumulation of water-carried ash, gravel, and boulders.

The finder at the left of this box is directed toward a heavily polished and scratched rock surface on the edge of the crater. This type of wear is known to be produced by slow movement of ice carrying sand, pebbles, and boulders. Glacial polish and thick beds of material carried by glaciers are common around the mountain. They are present on the surface rock and seem also to appear between earlier layers, showing that glaciers were present at various stages in the history of the mountain.

Broad valleys cut at various points around the crater are characteristic of glacial action. Kerr Notch is such an evidence of glacial erosion. It was through a similar ancient glacial notch that the lava at Llao Rock flowed out, as shown in the finder to the right of this box.

FORMING OF THE CRATER

View 5

Broken Edges of Layers on Crater Slopes Indicate Widening of Crater in All Directions by Breaking Away of Walls

The edges of rock layers inside the crater wall are clearly exposed because they have been sharply broken around the entire rim region. This fracturing took place in course of widening the crater. Increase in size of the opening at the summit of the mountain may have been caused by tremendous explosions, or by collapse of the peak, or by combination of such activities. The precise nature of the story is not yet fully known.

If the activity of a volcano diminishes slowly, growth of the mountain may end in forming a symmetrical cone. If activity continues by spasmodic outbursts, explosions may blow away a considerable part of the peak. Other conditions may bring about undermining of the walls in such manner as to produce a wide cauldron-like crater, but without tremendous explosions.

View 6

Latest Stage in Forming of the Crater, Eruptions Producing Wizard Island and Two Other Cones

If the lake were removed the crater would be seen as a relatively flat-floored cavity extending as a maximum about 2,000 feet below the present lake surface. In this great depression Wizard Island would appear as one of three small volcanic cones produced by pouring out of lava and cinders in the last period of volcanic activity. Forming of the present floor probably involved many stages, during some of which the cauldron-like crater may have been occupied by wide stretches of molten lava, as in the "lake of fire," at Kilauea, in Hawaii.

ORIGIN OF THE LAKE

View 7

The water of Crater Lake is derived from rainfall and snowfall over this crater region, together with snow blown into the depression. The lake is not known to have outlet except by seepage. The conditions of evaporation, seepage, and precipitation are in a state of balance which makes possible this accumulation of water and maintenance of approximately this water level. If the region were at a different altitude, or in a different location, the lake might not have been formed.

It is conceivable that in the course of late stages in its history, and under climatic conditions different from those of the present, the crater may at times have been filled in part with ice.

Existence of Crater Lake was made possible by building of a mountain, in the elevated summit of which there could be formed a wide and deep cavity having no outlet, except by seepage, and no inlet. The conditions required for accumulation of a body of water with the peculiar beauty of this lake are furnished in a crater produced by combination of those tremendous forces found in the power and heat of a volcano.

EXCEPTIONAL FEATURES IN BEAUTY OF THE LAKE

View 8

Color an Outstanding Character of Crater Lake

The color of Crater Lake is generally recognized as the most attractive feature of this region. Among spectacular lakes of the world there are none in which depth of color and brilliance of blue are more striking. The blue of the deeper water is brought out in contrast with the brilliant green of shallow areas along the margin.

The deep blue of the lake is believed to be caused chiefly by the scattering of light in water of exceptional depth and clearness. The color is thought to be due to the same cause that produces blue of the sky where light passes through deep atmosphere.

The extraordinary beauty of the lake arises in part from its great depth, clearness of the water and of the atmosphere above it, and from favorable conditions presented in viewing it from the high crater rim.

View 9

Beauty of the Lake in Relation to Its Surroundings

A thing of beauty may have its value enhanced by the setting in which it appears; so the attractiveness of this lake varies according to conditions under which it is seen. In the same way the beauty of other things may be increased by relation to the lake. Of many possible examples illustrating relation between the lake and its surroundings the following have been found of interest to visitors:

1. Beauty of color in the lake as seen through the screen of hemlocks from the path leading to Sinnott Memorial, and similarly as seen through trees at many points along the rim.
2. Form and reflection of Phantom Ship seen through the finder next this box. Smooth reflecting surface of the water is necessary.
3. Continuous changes of light produce a constantly varying picture. These conditions may be due to position of the sun, to the wind, and to reflections and shadows of clouds.
4. Reflections of cliffs and other shore features.

CONSERVATION AND EVOLUTION IN A CHANGING SOCIAL PROGRAM

The present national emergency has given us relatively high appreciation of three great groups of human problems. The first touches immediate relief of personal suffering and unemployment. A second concerns the devising of means by which dangers to social structure and function can be stayed until new adjustment is made. The third has to do with relation of present specific difficulties to the underlying conditions that determine stability, decadence, and progress of society.

In close relation to large-scale activities directed toward immediate relief of suffering, and operations designed to meet emergency conditions in business, effort is made to guide adjustment of the social program so as to give opportunity for constructive planning. While some see in favorable outcome of the present struggle only a possibility of return to so-called normal times, others accept readjustment as opening the way for progress.

Appreciation of the fact that dangers of the present are due in part to inadequate understanding of many great social questions has brought demand for more knowledge and better vision. In study of major trends in the changing social order, it is clear that one of the principal needs concerns determination of relative values among the almost infinite number of factors involved. For practical purposes of looking ahead on such a great program we should know:

First, what things represent essential and dependable elements upon which we can always build, and which we must therefore conserve or protect.

Second, what tends naturally to change or grow, and may be expected to continue its evolution.

And third, to what extent human constructive or creative ability should contribute toward betterment of conditions.

Address before the American Philosophical Society, March 2, 1934. *Proceedings of the American Philosophical Society*, vol. 73, no. 5, pp. 351–370, May, 1934.

Discovery of many evils in the institutions and activities of this period has tended to throw the shadow of suspicion over everything. And yet revolutionary overturn might be a more serious menace than existing evils. At such a time, knowledge of what is bad, and what may serve as basis for new building, and what must be looked upon as in a normal state of change, is indispensable, though to obtain it we require the most difficult among all types of judgment.

The enormous extent of detail in existing knowledge makes mastery of the entire range of materials impossible for any individual. Need of specialization in every subject has involved the interests of students to such an extent that few have looked over much of what is available with even approximation to reality. Lack of vision over the broad scope of information already secured is especially regrettable at a period in which it is essential to have somewhere a comprehensive view of science, history, sociology, government, as well as those values which we call spiritual. This situation makes important any useful means of balancing values in terms of their continuing influence.

As point of view is an important element in any discussion, it should be recognized that this paper is written from the position of one trained in science. But dangerous as is exploration by a scientist in the field of human values, it is also true that unless students in scientific subjects join with investigators of human problems to study relations among the several regions of thought, there is small hope for solving some of the questions for which we most urgently need understanding. It should be stated, further, that, in spite of need for specialization, science and the humanities are not separated in the world outside the laboratory. Somewhat as in the long-discussed "conflict of religion and science," the assumed clash between natural science and social science is possible only when there is interference with normal exchange of ideas.

Conservation and Evolution in Relation to Natural Resources

As seen by the student of natural science, what we call "conservation," "evolution," and the influences of human constructive activity have concrete illustration through our relation to nature and natural resources. In no other field do we have better appre-

ciation of need for understanding what is indispensable to us and requires protection, what must be allowed freedom for natural growth and development, and to what extent human creative activity may bring new values. In no other relation are values of conservation and evolution more clearly measurable in terms of a social program in process of change, or of a future for which we are not yet able to predict a conclusion. Although our relations to natural resources represent only a modest part of that complex group of problems so important in the present social crisis, they happen to constitute critical values in a number of the most significant emergency activities. These relations serve to illustrate point of view regarding conservation and evolution in our changing social program, and to emphasize the need for maintaining proper balance between these elements.

Civilization seems in some measure to have accustomed itself to the idea that, having come into control of new lands, new resources, and the wild places which once dominated the earth, it has in that conquest made the best use of all the benefits to be obtained from this contact. So long as new wildernesses with their virgin resources were still available for discovery and harvest, need of providing against the future was not appreciated. Nor had there come clearly into public consciousness the fact that there *is* a future against which to provide. Today there is realization that we see an end to this store of natural resources. Our desire to protect these possessions is now voiced in the word conservation, with its multitude of interpretations.

Situations similar to that of the present have arisen through all history with reference to natural resources of various regions as they concerned soil, mines, forests, water and other materials. In numerous ways measures for protection have been devised. But in no earlier period has the world with its resources been mapped out in such manner as to call attention definitely to distinctions between what is replaceable and what is non-replaceable. There has been only partial realization that for some materials there is practically only one supply, made, so to speak, when the earth was formed. Nor was it at first realized that other assets, such as forests, should continue to reproduce themselves, or in one sense that their growth and evolution might continue.

Conservation as the word has been used commonly in this coun-

try concerns halting the destruction of resources and certain questions touching ownership brought out in concentration of large public properties under private control. Government moved only slowly to correct abuses which had to do with wasteful or destructive processes. It could and did act more quickly to halt the movement toward concentration of control over great natural resources passing into private hands without adequate return to the people.

In the pioneering stage of this country it was possible to obtain land for farming purposes on comparatively easy terms. The profits were relatively sure, but not great in proportion to the labor expended. In the case of underground mineral wealth, difficulty of locating and testing properties was much larger. Operation was precarious business. At times the returns were of the bonanza type. The element of chance in finding and in realizing on properties made the process in general difficult for all but those prepared to invest relatively large sums in the hope ultimately of obtaining that which could give adequate return on investment.

In some measure the bonanza phase of operation was also to be expected in lumbering operations. Under methods involving harvesting of only one crop from a forest, large properties, large mills, and heavy investment seemed necessary. Methods which gave large returns generally involved also great waste, and frequently left only a bare landscape with little market value.

Rapid harvesting of what were originally the people's resources in natural wealth, along with concentration of these possessions in a limited group of owners, led to protest, to withdrawal of lands, and to modified control of development rights. It led also to better understanding of actual conditions of occurrence and to more careful study of procedure in harvesting.

Had the government many decades ago been able to carry to greater lengths its intensive study of actual conditions from the view of natural science, economic development, and governmental procedure for developing of these natural assets, much waste might have been avoided. Better distribution of wealth would have been possible, and a larger return could have come to the people. A study of history in this field reveals much of interest bearing upon relation between the individual right to discover, acquire, and develop and, on the other side, the public interest and responsibility.

Perhaps the country could afford to have its extraordinary experience in development and waste of natural resources in the period following the Civil War, if from this time on it can profit by the knowledge secured. But it should be clear that while experiences of the next stage of social development will grow out of situations in the past and present, unless the world modifies its habits completely we should expect many further changes in the next stage. These will involve conditions not heretofore recognized. If we are to avoid comparable or more unfortunate situations in the future, in addition to a full understanding of what we should have known and have applied in the past, we shall require much additional information on these subjects from the fields of science, economics, and government.

Conserving Non-replaceable Mineral Wealth

Adequate protection of so-called non-replaceable resources requires all possible data regarding their origin, occurrence, manner of synthesis, and means of recovery or harvesting. We should have exhaustive studies on the whole range of uses and possibilities of replacement by more abundant substitutes. Science, economics, and business should join hands in such investigations. For the benefit of posterity, the continuing people should give such support as is not easily furnished by private enterprise.

At the present stage in our study of resources of the non-replaceable type the problem has two outstanding phases: one concerns conservation in the sense of material protection, or guardianship; the other relates to evolution in types of use, and the extent to which human constructive activity can give aid for the future. The nature and degree of protection will be dependent in considerable measure upon the kinds of use. Use depends upon knowledge and desires of the people, and upon their wish to look upon the question as concerning their future.

This discussion thus far has seemed wholly academic, although I believe that it states unequivocal truth, which is never purely academic. What has been said would apply practically in most details to any one of several resources. Oil, or petroleum, illustrates every problem when considered through its history of varying scientific opinions as to origin, nature of occurrence, potential chemical contribution, the adventurous story of its com-

mercial development, of waste, control of ownership, and now of effort for adequate guidance of production through governmental relation. What has been said regarding future possibilities requiring intensive study in every direction also applies fully to this case. That this is recognized is made evident by the wide and deep research on these questions by those most intimately related to industrial development of this group of materials.

Maintaining Values of the Soil

The soil, the resource upon which man has been most dependent, has of all natural assets seemed the least susceptible to injury. We realize now not only that it suffers seriously through human influence, but that the damage may amount almost to destruction. Without considering what is taken from the ground through unregulated crops, its fertility is reduced. With no appreciation of influence by tilling and lack of control for wash or drainage, erosion carries away much of its value. In absence of a vegetation cover, exposed areas may be subject to rapid denudation.

Production of a fertile soil may represent ages of preparation by natural process. The work of man can go far to destroy major values within a few years. Wide studies of soil treatment and artificial fertilization have gone far to remedy some of the evils. The major effects of erosion over large areas have been a continuing menace to mankind.

Erosion as a process results from interaction of two groups of natural activities, seen in geological forces expressed as movement of the land and in precipitation, of which neither can be controlled by man. Upward movement of the earth's crust increases the power of running water to wash and cut. This process has been under way through hundreds of millions of years and can be expected to continue for a comparable period.

Regulation of erosion through control of drainage lines and vegetation cover can be planned and guided by man. The influence of unwise tillage, and exposure of areas to increased wash, can be so modified as to limit the detrimental effects.

Based upon thorough study of the factors involved, projects of the government designed to conserve fundamental values of the soil, and to preserve the soil itself, can contribute enormously to conservation of a resource which if seriously impaired can be re-

placed only with infinite difficulty. In this, as in other cases cited, the need of the moment is for basic knowledge in a wide range of subjects including geological processes and their application to erosion, also soil structure, soil physics and chemistry, climates and meteorology, as also plant cover and its evolution with reference to soil protection.

As in the case of other conservation problems, decisions regarding uses to which the land should be put have great importance. These questions require for their solution an understanding both of evolution in social organization and of the real desires, purposes, and aspirations of the people concerned.

From another point of view it is important to bear in mind that while the progress of erosion and of soil formation is to be considered as a fundamental or basic phenomenon so far as development of our civilization is involved, it is also true that the process is evolutionary. Crustal movements and erosion processes go forward in cycles, which collectively give us a large part of the story of the earth through recorded geological time. We may adjust ourselves to the stages of these cycles in such manner as to continue use of the soil, but we can not halt the evolutionary development as it advances.

Permitting Continuing Growth and Evolution of the Forest

Contrasted sharply in most respects with the conservation problem as it touches non-replaceable mineral wealth are the questions involved in use of natural resources of the biological type. Among these features of our environment at the moment outstanding questions are presented by forests and grazing. Of much significance for the future is also the conservation problem relating to wild plants and animals not now in practical economic use.

The executive action of President Cleveland in 1897 which withdrew from private entry large areas of timber land under government ownership was prompted by discovery of rapid destruction of the forests. With subsequent government control harvesting of timber on these areas was carried out according to principles under which the forest was looked upon as a growing, reproducing feature, and not as a single crop to be gathered without reference to the future. The wooded lands came to be considered not merely as a resource of value for the moment, but as something in

itself subject to changes the understanding of which is essential to any plan we make for continuing use.

In control of forests, as in administration of non-replaceable resources, it became necessary to obtain knowledge of every factor concerned. This involved the soils upon which trees grow considered in the light of chemistry, physics, and bacteriology. It was necessary to know the story of climate and of associated plants. It became essential also to have acquaintance with every detail of structure, physiology, reproduction, growth process, and decadent stages of the tree. In ultimate adjustment to this information must come all practices that have to do with harvesting, or in any way touch protection of the soil, or concern the cycles of development in replacement of a forest.

Guaranteeing Protection and Continuing Evolution of Wild Life

Viewed at one time only as a plaything of the scientist or nature lover, wild plant life not now in economic use may become of critical importance in evolution of society. That the domesticated plants upon which man depends so largely for food, clothing, protection, medication, and many other values constitute all available elements of the plant world that have such value is extremely doubtful.

The plant species at present in use were obtained by ancient peoples through ages of contact. Attention was centered on cultivation and betterment of these materials. Either emergency conditions or intensive research will bring out still other species having hitherto unrecognized values.

During the Great War, when we were in search for rubber supply, it was estimated that one billion pounds of rubber could be obtained from the rabbit brush of the arid region in and bordering Nevada. Perhaps future studies of land use will make desirable some development of this resource through bettered strains of this and similar plants in regions where other agricultural ventures are less profitable.

One may expect that in future ages scientific discovery will give us yet undreamed methods for modification of the plant world to meet new human needs. But it is highly improbable that such researches will furnish us a range of new species comparable to

those now found in the wild flora that has been produced through hundreds of millions of years of evolution in the environment of a constantly changing earth. It is essential that guardianship of such relics as we have be maintained, and that careful research be directed toward study of possible resources for the future.

So again in wild animal life, the great resource of game animals and other creatures remaining in the wild state deserves our protection for possibilities represented in a multitude of uses. These range from food, recreation, and stimulating experience of the hunter, to interest in such life for its own sake that serves an increasingly important purpose as opportunity develops for us to turn again toward the values of nature.

Conservation of Great Natural Features in their Primitive Condition

One of the most difficult, and yet in some ways one of the most important, functions of conservation at this time looks in still another direction toward preservation and protection of those overshadowing features of nature which illustrate both the processes and the results that have contributed toward shaping the world as we find it. Such aspects of our surroundings appear in the power of natural forces, in the primitive life which has grown out of the creative process, and in great landscapes comprising the whole range of features in nature.

The values maintained in this type of conservation or protection, and the uses toward which they contribute, comprise an infinite variety of things relating to aspects of life which concern our maintenance through food, shelter, control of power, and knowledge of the entire range of natural resources. In at least equally important ways they meet needs touching the things that are most strikingly characteristic of man, namely, his intellectual growth, his appreciation of beauty and sublimity in nature, and the desire to adjust his spiritual or religious life to what is known of creative influences in the world about us.

It is a part of the task of science to make acquaintance with the elements of our natural surroundings. Nature is almost infinitely complex, and to know it adequately we must study its operations without the disturbing or complicating influence of artificial fac-

tors. So from time to time areas which present exceptional features have been set aside for complete protection.

The manner in which various human uses may be intertwined in such possessions is illustrated in simple manner by the sacred forests surrounding ancient temples in China. These wooded areas seem to have been maintained partly to give protection to the temples, partly by reason of their beauty as frames for these structures, but largely because they were places in which it was possible to walk in quiet natural surroundings and to meditate on great questions of life and religion. This desire for contemplation in in the midst of undisturbed natural beauty, which made the preservation of these wooded areas possible, has brought most interesting results.

Dr. Lowdermilk, of the federal Soil Erosion Service, a close student of problems in China, tells me that the sacred forests are almost the only places in those regions where the natural features have been left undisturbed. It is here that he found opportunity to compare the original face of the land with the heavily eroded areas of today. It is in such forests alone that the beautiful maiden-hair, or gingko tree, which was once spread widely over the northern hemisphere, remains now for our use and study. It is here that, in the desire to maintain nature as nearly as possible in its original condition, certain areas, that have been used in some part to meet needs of the community, have long been treated by methods of forest conservation corresponding to what we are at this moment initiating as a national practice of the United States through the timber conservation policy.

Protection of great features of nature which illustrate outstanding results of creation, or of the processes by which this work has been accomplished, is especially important when what is guarded remains in its primeval environment. Only with such conditions can we have real appreciation of nature at work, and of the conditions under which its activity proceeds.

Conservation of Natural Beauty

In addition to what might be called the creational values of nature which we may protect for future students, scientific, intellectual, and economic, strong emphasis should be placed on that significant phase of conservation covering the diverse elements

which human appreciation groups under the head of beauty in nature. On the assumption that beauty represents only an attitude of mind toward harmonious values, we must recognize this point of view as connected with that relating to the element of the sublime in nature expressing respect for things of magnitude and power. Though beauty may be dependent upon how we look, or the point of view which we take, the elements combined to form the picture of beauty and sublimity must be conceived as existing in nature and not wholly due to human imagination.

So conservation as it touches nature should cover features representing beauty and sublimity and the great group of influences which inspire us. Through this guardianship we protect materials that serve as the source from which may develop critical elements not only of scientific thought, but of æsthetic ideals, or even ideas of significance in growth of religious thought.

Necessity for Evolution of Highest Attainable Standards of Use for Great Treasures in Nature

Building of the National Park system of the United States offers one of the exceptional possibilities for preserving features in nature recognized as superlative from points of view ranging through economic and scientific to the æsthetic, poetic, and religious. Maintenance of these values as they have been transmitted to us, and guidance of their use for scientific, intellectual, and spiritual purposes, constitute one of the unique responsibilities of the world.

Proper development of the opportunity furnished for study of creation, its processes, and the relation of man to it will require a synthesis of all that we possess in science, in art, and in philosophy. The result will conceivably furnish a new aspect of intellectual and spiritual interest having large significance in the future development of our beliefs regarding the relation of man to nature. It will be an outstanding influence both in conservation of ideas and in evolution of ideals. So important may this contribution be to a world of changing and developing views that no effort should be spared to maintain the treasures set aside for this purpose. It is important to realize that adequacy of protection depends upon ability so to define the values and manner of use for what is involved that unwitting destruction will be avoided.

Conservation and Evolution in the Field of Human Activities

In the region of nature we have come to an appreciation of our responsibilities for protection of basic resources, and for continuing study of their utilization in such manner as to meet requirements in the evolution of our highest needs. We do not understand the balance of these functions fully, but we appreciate the significance of the problem.

Within the special domain of human problems, determination of what requires conservation, what concerns evolution or development, and what is clearly the peculiar opportunity for man's constructive ability is more difficult than in examination of our relation to nature. There are nevertheless in the phenomena of life, whether considered as biological or in terms of human thought, certain things which the tests of time and experience show to be fundamental. In other aspects of life we find expectation of change and development or growth inherent in the situation. And again there are conditions in which the stage seems set specifically as opportunity for human creative activity. The possibility of orderly movement in social development depends in considerable measure upon our ability to determine the balance which should obtain among these factors. This is one of the greatest of all human questions.

The view that there are *no* basic or fundamental qualities means a situation in which changes will be largely dependent upon the momentary whims of individuals or groups. In common language this is chaos. On the other hand, inflexible adherence to the idea that *nothing* changes results in attempt to tie down the growing structure of society. The result is that sooner or later the bonds are rudely broken. Appreciation of the idea that society *desires* opportunity for *progress* opens the way for those processes of growth by which changes, sometimes slow and sometimes rapid, bring about normal evolution.

The known history of the world permits us to visualize the entrance of man into the scheme of things at some remote period, and to see him bringing a new constructive element. The coming of this influence gave added possibilities for organizing and storing knowledge, and finally for selective judgment. Whether one looks

upon the appearance of human kind as only another expression of the Creator, or however it be interpreted, with its coming a further type of vision opened in the world. With increasing knowledge of nature and of man himself, previously unknown combinations were made possible, and under these conditions forward building was to be expected in all later stages.

Opportunity for Conservation and Evolution in Aboriginal American Culture

In human application of conservation and evolution principles derived from study of nature, we find illustration of an activity having much significance today in a program under discussion for widening opportunities of life for the native or Indian peoples of this country. With differing views as to how this may be accomplished, consideration is being given to adjustment such as can guarantee to the Indian the possibility of following as he may wish the ideas or ideals which his nature or his culture indicates as most desirable.

Of the courses which can be followed one possibility looks toward early amalgamation of all the peoples of the country, and possible assumption of characteristics like those distinguishing the Anglo-Saxon people. From another point of view, there would be recognized in human nature an assortment of qualities which are in part expression of individual peculiarities, but in large measure represent more fundamental strata corresponding to influence of inheritance and environment.

This particular problem concerns extent to which the aboriginal American may be given opportunity to develop on the basis of conservation of his fundamental characters, inclinations, and ideals. It involves also the extent to which in his evolution he should have aid in accommodating himself so far as he may desire to the conventions of European civilization. It has taken the cultural groups of Europe many generations to attain appreciation of the fact that the things which appear good to one nation, or in one culture, may not have comparable value to those representing development out of a different environment, and on the basis of different ideals. The world is still seeking for light as to how such problems should be solved.

Significance of Conservation and Evolution in Practical Questions of Society Today

When we turn to application of conservation and evolution principles as they relate to the particular problems of our civilization in this period of depression one can not avoid recognizing first of all the seemingly infinite extent and complication of forces in action. The picture is today so vast, and the factors concerned so little understood, that the problem is impressive by reason of almost incomprehensible magnitudes and through recognition of our ignorance. The tremendous difficulties of the situation make it more clear at the present time than at any earlier moment in history that, within reasonable limits, we must determine what among the elements of science, economics, government, and religion appears to be firm ground upon which we can build, also what must be looked upon as in normal change or progress. And again we see that it is important to recognize those situations in which failure to act constructively might be tantamount to neglect of responsibility.

With what may be called the modern fact-finding view, we appreciate that determination of what is basic and of continuing value and what is of progressive or evolutionary type can be determined only by intensive examination of the facts. In this effort the combination of science and history with consideration of moral and ethical values becomes important far beyond the degree of acquaintance with this relation in any previous age. We have too often considered as practical only the things of immediate or personal significance. In reality practical values involve a wider vision concerning the highest truth and greatest good over the longer period.

While the principles of conservation and evolution can not be expected to apply to the affairs of man in precisely the manner in which we see them related to factors in nature, they are as clearly fundamental as in the remainder of the created world. This may be illustrated by the fact that in this country our political organization rests practically upon a two-party system consisting of a conservative and a liberal group. In general, one body stands more especially for conservation and development of certain great fundamental ideas or practices. The other inclines toward freedom

of action and to introduction of new elements. As political bodies they may almost completely exchange places, but the distinguishing principle remains.

In another direction it is interesting to note that just as we have studied conservation of natural resources with reference to values involved in ownership, and in control, and have taken measures so to regulate conditions as to give better protection of values and wider liberty of opportunity to the public, so at this moment we are deeply concerned with what might be called the bonanza aspect of money-making illustrated by forms of high finance. Great fortunes of the bonanza type derived from natural resources seemed in the past too frequently to represent private control of what had been derived from public ownership, with inadequate return to the people. Today we are concerned over possibilities of financial control which might permit gathering of large fortunes by methods not clearly representing true earning power.

Study of means by which activities permitting great concentrations of wealth may be guided look toward protection of something which arises in large part from constructive activity of the whole people. The concentration of money power of the nation in the hands of a small group might center control of other activities, including educational and intellectual opportunity, or even guidance of ideas. The process involved in conserving freedom for action is in some respects not unrelated to conservation activities developed in relation to natural resources.

We find in this age vigorous effort to eliminate poverty and secure opportunity for education and the broader view for all citizens. With this are coupled in some measure the activities designed to prevent great concentration of wealth by opening better means for its distribution. These questions are all related to fundamental principles concerning right of the individual to live his own life and grow in proportion to his capacity for development. This condition has been described through the ages in many ways and in numerous languages. It has been called liberty, or opportunity, or the pursuit of happiness. It rests upon ideas of life and government that involve both individual opportunity and responsibility to the community. The principles of truth, honesty, and brotherly love have worked themselves out slowly in relation to these aspects of control in possession of property, in

general human relations, and in government. They lie in a stratum deeper than laws or codes. It is the spirit of conduct and not the letter of laws that determines truth, honesty, and broadly all human values.

Much of the struggle in which we are engaged at the moment in this country, and in the world, ranges within the limits of the few principles or questions discussed. The conservation and continuing high use of great human ideals demonstrated over and over in history, but abundantly neglected in practice, is one of the most critical needs of this time. Standards of conduct are more fundamental than any other bases of reference. There is properly and necessarily strenuous discussion regarding intricate questions of economic and social organization, and this must all be given full consideration and much research. But in proportion to values involved, it sometimes seems as if there is less said about the fundamental principles underlying right conduct of business and of human relations, individual, national, and international, than of immediate technical details that represent evolution of our social structure. We have just spent many painful years considering individual liberty as it touches constitutional rights involved in prohibition legislation. In the meantime the cause of temperance has at times appeared less important than the right to drink.

Evolution of Creative Activity in Relation to Welfare of Society

In considering more especially those features of present-day life that have to do with evolution of society and expression of human creative activity, science in its varying forms has been given a prominent place. Few other types of activity have been looked upon as having so large a responsibility for present lack of social adjustment. It is not that science has been considered in itself evil or destructive, but rather that through its advance there has come into the world an almost infinite number of new forces, methods, and instruments causing tremendously rapid development in certain directions as compared with limited possibilities in others. The resulting unbalance has appeared to affect all aspects of human thought and activity. In a period of depression this relation takes on special importance.

Question has naturally arisen as to the attitude we should take

toward these elements which tend to promote exceptionally rapid evolution in civilization, or in another view might be looked upon as over-emphasis on human creative activity. While this development has been most strongly expressed in the physical sciences, no phase of thinking, from physics to social theory, has failed to exert its influence through production of new materials.

In the great mass of new information contributed by this constructive work the product is such that under proper conditions of control it would be recognized as having large value. It is principally those things which are advanced or promoted without reference to their wider or ultimate human significance that come to be looked upon as detrimental. This may be true of forms of energy, mechanical inventions, chemical substances, drugs, aspects of art and literature, or theories of social organization.

We can not doubt that from time to time discovery and invention have brought difficult social disturbance. The results are not unlike numerous known cases in which plants or animals have been moved into a region not adjusted to their presence, and have disturbed the balance of nature. Such is the story of the cactus, or of rabbits brought into the Australian region, where such types of organisms had not existed in this or any preceding period. At the same time there seems no question that with adequate vision these new products or advances in knowledge collectively are of benefit to mankind. They present possibilities for adjustment on new levels, and with widened opportunities for life.

The control of new features will in many instances require a view such as can be obtained only by wisdom of the highest order. Perhaps we shall need the collective judgment of many minds related in an exceptionally effective way. In other cases the necessary action may arise from individuals concerned. To depend wholly upon values remaining through survival of the fittest, allowing things to take their course unguided, will sometimes involve fate of the product and on other occasions the interests of the people. Errors of ignorance in handling of such situations will be multiplied by bad judgment, and may be increased almost infinitely by selfishness or neglect of the public interest.

In ways not yet devised we need development of research, education, and vision which will give us machinery making possible the continuing evolution of society through creative activity, but

without increasing the dangers. Such a program will necessarily involve participation of science and engineering in its various phases, along with representation of all social interests concerned.

Desire and ability to increase knowledge and extend creative work are normal and essential characters of an intelligent people. To halt such activities would be to limit that forward movement which is indispensable in a world of people whose happiness is in large part determined by their opportunities for progress.

We have adequate knowledge from history to indicate that we live in a changing or evolving world, and this need not now be disputed or argued. We know also that adequate development through the varying stages of life depends upon the working out of great principles and ideas. As the movement continues we must retain and conserve the things which are fundamental and at the same time give liberal room for changing elements, with normal evolution and creative activity such as enter at every age. With this continuing development there is no problem more important than that of maintaining balanced judgment and means of adjustment adequate to progress with the minimum of loss and the maximum of value for constructive effort.

Let us not be deceived into setting up an alibi through thinking that science has disturbed the values of truth, or that real business necessarily makes exchange and barter unholy, or that natural passion and art demean the spirit of man. Perhaps in application of principles of conservation and evolution to human affairs we need the voice of the preacher along with that of the scientist, engineer, economist, and student of government to tell us whether the scales of our judgment are properly adjusted. If such balance can be maintained as will give true appraisal of relations between major values, the way for progress will be seen as a wide and pleasant road.

SCIENCE AND CONSERVATION

The conservation movement in the United States has passed through three principal phases. The first two concern the idea of protection as designed to prevent destructive exploitation and undue concentration in private hands of properties derived from public ownership. The third phase relates to development of the highest use of resources. Exceptional illustration of this third aspect of conservation is given in discovery of new modes of utilization for petroleum. From consumption through burning of oil for light or fuel we attain a stage in which these products find a vast range of application in all manner of chemical compounds valuable for industries as also those having special application for medication.

The relation of science to conservation has been important in all these phases. There has been large contribution in determining the occurrence and nature of natural resources. This has enabled us to harvest or gather the materials in such manner as to limit waste. In consideration of new uses science and engineering have had leading parts. These advances were made possible both by extensive application of available knowledge and by new researches in chemistry, physics, biology and many other fields of science. This program gave a vast number of products which have helped to make life more agreeable and more profitable. It increased the types of employment and extended the range of human interests. It is a responsibility of science to devote itself in the most effective way to fundamental and to applied research which may extend the uses of the vast resources with which this country is blessed.

The term conservation has widened from its original narrow limits to express in a great variety of ways activities which have to do with maintenance and extension of values in many types of human activity. As a second phase of this discussion, I think it important to call attention to certain conservation aspects of the great educational program upon which advance of science depends.

Remarks before the National Academy of Sciences, Washington, April 24, 1934. *Science*, n. s., vol. 79, no. 2057, pp. 496–497, June 1, 1934.

In our educational system we attempt to furnish for youth a concentrated statement of available information and experience and to give a point of view which will make possible the most thoughtful and constructive attitude toward life. With particular reference to science, we present an outline defining in some measure the nature of the materials and the forces which constitute the scene of human life. We are now beginning to realize that this effort depends for its success upon our ability to develop a program which will maintain its value through the period of maturity. To state the problem in another way: we support an educational system which should have continuing and increasing influence upon later life, and we find that unless special means are developed for maintenance of this influence, a large part of the original effort is lost for the period in which it should be most effective. The broad plan for continuing education of the adult to-day is designed in a measure for conservation of the values secured in early education. Along with this influence we seek to open the way for evolution or development of the individual through his whole life.

As a third phase of this statement, it is important to call attention to the fact that we need, just at this time, to protect as fully as possible the exceptional opportunity which has come to science and research for bettering conditions of life in nearly every aspect of human activity. With science in the wider sense, including natural science, social science and governmental science, having won high place in the world, we have reached a stage at which question is raised insistently as to possible disturbing influence of science and research upon the course of civilization. It is stated frequently, and from many directions, that the influence of science is in large part responsible for the difficulties in which the world finds itself to-day. We discuss seriously whether science is an asset or a liability. We consider the possibility that a moratorium be established on research.

From my point of view there is no doubt that the opportunities offered for creative work are essential for maintaining the happiness of mankind. In one aspect of the question research may be considered the hope of a changing world, in that it offers a continuing supply of new materials with which to build and opportunity for adequate adjustment to shifting conditions. Seen from another angle, there is no doubt that the introduction of new ideas, how-

ever valuable they are intrinsically, unless guarded with extreme care, may produce unfortunate situations. What we call unemployment may be a result, not because research necessarily leads to unemployment but because of the difficulty in attaining immediate adjustment to things which may have great basic values for mankind.

The situation which arises through introduction of new ideas in a world which has not been prepared for them is in some respects not unlike that which may occur in bringing a new biological element, or an element from another region, into a part of the world adjusted through millions of years to a particular biological balance. The mongoose was introduced into Jamaica in order to kill rats. The experiment proved that the mongoose also kills all ground birds and destroys nests and may become an intolerable pest. The rabbit, a peaceful and in many ways useful creature, brought into Australia becomes a serious problem. So a new idea brought into use through physics or chemistry or study of social theory may come into a world not yet prepared for its use, and unless carefully guarded may contribute toward development of an unbalanced situation.

With reference to the possibilities of unbalance, it is my feeling that we are faced at this moment with a need for what might be called conservation of opportunity for science. With the way open for enormous contributions, which may well bring blessings to mankind, we must protect or conserve the positive opportunities for advance through warding off dangers which might lead to restriction of constructive science. The situation of science is endangered by failure to set up such relations as will furnish the most careful guidance in the introduction of new elements arising from creative work. This protection, or conservation, of the opportunity for great achievement, which intelligence has gained after fighting its way through tens of thousands of years, is one of the greatests needs of the moment. Development of means for adjustment in this situation depends in part upon those who study mankind from the point of view of social sciences, in part upon economists and in part upon students of government. There is also an unavoidable responsibility resting upon science itself so to fit the contribution which it makes into the general scheme of human life as to give the greatest advantage with the minimum of possible disturbance.

THE ORIGIN OF HENRY VAN DYKE'S POEM ON THE GRAND CANYON

Literature concerning great natural features includes two principal types of writing; one presents description or record of things observed, the other gives us personal or human impressions of what is seen. Though description furnishes essential information, it may not give as accurate an idea of reality as is contributed through the medium of what we sometimes call human appreciation.

For anything possessing as many extraordinary features as the Grand Canyon, it is not to be expected that an adequate representation will be found in description alone. Nor is it to be assumed that any single statement concerning human appreciation will be wholly satisfactory for every one. The most effective picturing may be discovered in a human impression combined with details of description, or it may arise through expression of a human reaction that is in some measure built out of our inheritance from age-long experience in the spiritual life of mankind.

Although the poet is commonly recognized as having such liberty in use of facts that his writings are not to be considered of special value as description of nature, at times his form of statement carries the effect of reality in a manner rarely attained by rigorously accurate scientific description. Such, for example, is the value of the following lines in Tennyson's description of erosion:

> The hills are shadows, and they flow
> From form to form, and nothing stands.
> They pass like clouds, the solid lands.
> Like clouds they shape themselves and go.

No other picture has presented so clear a vision of what one senses in the atmosphere and in changing forms of the land at Grand Canyon.

Henry Van Dyke's poem, addressed to "The Grand Canyon"

"History and Exploration of the Grand Canyon Region," *Grand Canyon Natural History Association, Natural History Bulletin No. 2,* pp. 7–9, November 1935.

must be classed among the greater efforts to formulate something of the impression made by the Canyon. The origin of these verses illustrates the manner in which a statement that is not narrowly descriptive may convey an idea of reality in terms of human appreciation, when an attempt to delineate elements closely might fail to satisfy the purpose in view.

In a conversation with Dr. Van Dyke some years ago I learned that he had twice visited Grand Canyon with the idea of writing a poem such as was finally embodied in his well known verses. On each occasion, with all of the materials before him, he failed to develop a satisfactory description or conception and left, despairing of ever creating anything approaching his ideal.

After his second attempt to produce a satisfactory picture of the Canyon, Dr. Van Dyke visited one of the Pacific Coast cities where, in an upper story of a large hotel, in the midst of the hurry of business activities, there came to him the ideas he desired.

In giving the story of this experience, Dr. Van Dyke left with me the impression that, on his two visits to the Canyon, study of the multitude of beautiful and sublime objects immediately before him brought such a wealth of thought that selection and definition of the greatest attributes seemed impossible.

Only when from a distance in space and time values of the lesser elements began to fade was he aware of the things so overwhelmingly important that their imprint on his mind remained clear and in proper relation to the picture as a whole.

Among the lines in Van Dyke's poem on the Grand Canyon that are especially impressive one finds the following:

> Thou vast profound, primeval hiding place
>   of ancient secrets . . . .
> Art thou a grave, a prison, or a shrine?
>
> . . . . A living silence breathes
> Perpetual incense from thy dim abyss.
>
> Yet no confusion fills the awful chasm;
> But spacious order and a sense of peace
> Brood over all.
>
> Who gave thee power upon the soul of man
> To lift him up through wonder into joy?
>
> Now far beyond all language and all art
> The secret of thy stillness lies unveiled
> . . . . This is holy ground,
> Thou art no grave, no prison, but a shrine.

HUMAN VALUES IN NATURAL RESOURCES

Each generation has opportunity for recording its name as benefactor of mankind. The possibilities for treatment differ with each period. At each stage the field must be examined, both to discover what previous work needs completion and to learn what new aspects of construction are required.

In the study of mechanical, scientific, cultural, and experimental advances we are now attempting to learn the place of America in adding to things of value in life. Mechanical devices and new aspects of government will be placed to our credit. Is it possible that we shall also make great contribution in sciences, the arts, music, painting and literature, already so far advanced? Development and creation in these subjects are due mainly to work in other countries. What may we expect to be the contribution of America?

I have been thinking particularly on the relation of America to science as touching the field of nature, but not wholly with reference to the point of view of science. In this country we have had among the greatest opportunities offered to any people for advance in the study of nature. Within the past two generations we have been given a very extraordinary opportunity on the one hand for development of natural resources, in another direction for scientific or intellectual study of nature, and in still another direction for a new statement of values in the spiritual appreciation of nature.

I feel safe in stating that not in any other country has there been a greater development of natural resources than that in the United States in the course of the past seventy-five years. We have developed forests, iron, copper, coal, oil. This has led to building up of great wealth, which in turn has been used in very many important ways.

In development of these natural resources there have come many difficulties, some of which we are just now attempting to smooth

Address before the American Council on Education, Washington, May 5, 1933. *Educational Record*, vol. 14, no. 3, pp. 296–300, July 1933; in revised and abridged form, *National Parks Bulletin*, vol. 13, no. 61, pp. 5–6, February 1936.

over by legislation. Along with the accumulation of the great fortunes by lumber barons, coal kings, and oil operators, great educational and scientific institutions of many types have been made possible.

On the scientific side, as well as in the development of natural resources, there has been extraordinary advance in the United States within the last generation and a half. Out of this movement have come great men, and great ideas, so that in measuring the progress of science in America against that of other countries there will be a record of which we shall not be ashamed.

In the development of our natural resources, the advance of science tended to promote a new phase of the conservation program. Conservation was initiated in order to obtain for the people title to many great resources which might otherwise have been absorbed by individuals, and in some part wasted. This movement at the beginning was mainly protective. In time there came a new aspect of conservation which concerned promotion of the highest uses of these resources, such as is made possible by better understanding of our needs and of better means for handling. So there came the advanced physical and mechanical development, which led to modern production in coal mines, iron mines, and forests. And there has come also the development of fundamental sciences underlying these various projects.

Science, then, has developed along with the use of these natural products, and has given us a position in which we are obtaining relatively large values from our resources.

But there is another extremely important aspect of the use for natural resources, and that is the phase which concerns interest in and appreciation of nature. It is not my purpose to discuss at length what appreciation of nature is, or the many directions in which it may go. I do wish to point out certain phases of the problem before us at the moment.

Younghusband, the Himalayan explorer, said some years ago that nature presented its most favorable aspect under either of two conditions. One was nature completely under the control of man, as illustrated by the great estates of England; the other was nature completely primitive, as represented by the forests and mountains of the Himalayan region. I agree with him that there are these two exceptional conditions.

So in America today, in our use of nature for its spiritual values, we may view it either as under control of man, or as completely primitive, as God made it. We must also decide how far we shall go in this country in development of landscape art, protection of our roadsides, and the beautification of the country. Again we must decide what we wish to do regarding nature in its primitive state, where there is assumed to be opportunity for discovering what a Creator may have desired to do before man put his hand to the task of modifying the face of the land.

Shifting from these points for one moment, there is another aspect of the problem of nature that should be mentioned, and that is not what we do to develop nature or to protect it, but what we do to develop our enjoyment of it. This is a region of thought in which great advance has been made in other countries, and to some extent in our own. Outstanding accomplishments are those of Wordsworth, and in some measure Tennyson with other English writers. Wordsworth stands out among them all. I saw recently on the fly-leaf of a copy of Wordsworth, lines from Matthew Arnold: "But where will Europe's latter hour again find Wordsworth's healing power?" Does anyone equal him today?

Wordsworth emphasized enjoyment of these things as coming from within. It was he who indicated that if interest in nature and pleasure in its enjoyment are once developed we have something that gives a light in life wherever we may be. Such is the message in Wordsworth's poem:

> Thanks to the human heart by which we live,
> Thanks to its tenderness, its hopes and fears;
> To me the meanest flower that blows can give
> Thoughts that do often lie too deep for tears.

That is, to be sure, only a point of view, but it means putting into the lives of great numbers of people something that has given enjoyment and has a healing value, such as is perhaps not found in any other way.

So when we come to consider what America is doing with reference to nature, we are faced with the fact that we have developed our natural resources, we have made great fortunes, we are attempting to protect them in the commercial sense. We have used great fortunes for the development of science and of education,

and have benefited greatly in these directions. We are attempting to develop landscape art in order to express beauty through nature. If, for example, you go from this building into the park across the way, you will find something to gladden the heart at any time of day or night, or in any season of the year.

We are also attempting to do what I believe to be one of the great, critical things needed in the world at the present moment, that is, to preserve somewhere something from the original face of nature in such way that later generations may at least know what the Creator was attempting to do when he made the pleasant lands, and the sublime regions where sometimes men worship. Protection and interpretation of nature in that sense give an opportunity comparable to development of a great art like literature or painting. There is here a thing of primary importance both to intellectual and to spiritual life of the future. Probably nowhere in the world at the present time can this be done so effectively as in the United States. We are just at the end of a pioneer period when we recognize that unmodified nature is vanishing. We have the money, and the energy, and the intelligence to do it. We are trying but we need guidance, and we need support to carry it through.

There is no substitute for ideals or idealism in the development of a program of this nature; just as there is no substitute for the kind of idealism presented by Wordsworth, by Tennyson, by Ruskin, and others in matters concerning both relation of man to nature and significance of nature to man. We need at this moment, as much as any country ever needed it, the development of that phase of literature, or shall I call it that phase of science, which makes clear the influence of nature upon intellectual and spiritual life.

We need today an integration that involves science, the arts, and human interest in order to give clear expression to what is most significant in our relation to nature. There is no period in which the kind of influence that might be produced by such integrated knowledge would be of more value than in a time of depression. In war we are stimulated to a high level of effort. Depression is a period when healing has its greatest value.

Regarding the present political or economic situation, I am inclined to be optimistic and to believe that we have turned the

corner. I sometimes wonder whether this is not due to the fact that nature, having passed again into the cycle of change, has brought us spring. There is nothing greater in the world than the expanding, freshening life of spring, wherever you may find it, in this land or any other, at this or any other time.

Last fall I heard Alfred Noyes on a very interesting occasion make the statement that if spring could come but once, if there could never be more than one cherry tree to bloom or if it blossomed only once in a thousand years, how the scientists and the poets and the artists would look forward to that day. How the world would gather to see spring open and the tree bloom.

SHELLEY AND MEN OF SCIENCE

SHELLEY exhibited almost unbelievable appreciation of the fact that what we see in the world about is only a superficial picture of great elements in the background. His statement, "How glorious art thou, earth, And if thou be the shadow of some spirit lovelier still," is only one illustration of this point of view. In referring to the great White Mountain of the Alps, he expressed the same idea in his lines: "The secret strength of things which governs thought, and to the infinite dome of heaven is as a law, inhabits thee!" In these views in some measure he foreshadowed the present attitude of physics relative to what lies behind the infinitesimals of matter, and, on the other hand, he expressed the idea of something more than stark nature in the mountain mass. It would be interesting to know whether in the coming ages there will arise one able to present the intimate appreciation of nature with higher art than that of Shelley.

I am a good deal concerned over the tendency of extreme specialization in the world at this time. Many scientists are interested wholly in science. Others, concerned only with cultural activities, look upon culture only in the passive sense, rather than with the broader view that I wish to see taken. My own concern is that we develop the right relation between the peculiar urge of science at the present moment and that broad vision of knowledge represented by culture. I would say that if science is an attitude of mind which has to do with the securing of facts, and their organization and their presentation, culture is that highest refinement of our appreciation of knowledge in the most comprehensive sense. It is the attitude that represents the full view of things, covering all that touches the human mind, and putting each phase of knowledge in its proper relation to others.

Experience in educational institutions made it clear to me many years ago that science has an increasing responsibility for bringing into our lives a better acquaintance with nature as we see it in every-

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day experience. This may be done by learning to know the flower in the crannied wall. For many it can be accomplished by sight of some great thing in nature which shocks us into attention, and opens the windows of our souls so effectively that they never again close completely against the wonders and beauties of the world. The Grand Canyon is a place where the light of understanding strikes deeply, and one's whole being is stirred. In that place most of the smaller things relating to our personal experience are not observed. It is the greater features involved in beauty of color and form, and in magnitude and force, that make the most profound impression. There are few, if any, regions where sensuous beauty expresses itself with greater effect than is shown in the unmatched architecture, in the colors spread in ways we have not known, and in the varying hues of atmosphere and sky. There are no places where the measure of a physical abyss impresses upon us more deeply the influence of majesty and power. In his best vein Van Dyke wrote regarding the influence upon us of the great work done by the Colorado River in cutting the canyon, as he speaks to the river in the words: "Who gave thee power upon the soul of man to lift him up through wonder into joy?"

Another attitude toward the world around us is that sometimes referred to as "companionship with nature." Byron said he loved "not man the less, but nature more." Wordsworth remarked that "nature never did betray the heart that loved her." Any person, without being a poet, philosopher, theologian, artist, may have the same feeling of relationship, never defined, but always in the background as something valued beyond measure in the scheme of living. Colonel Tallboys in the play "Too True to Be Good" remarked, "Humanity always fails me. Nature never." No work of art seems ever to have expressed in comparable measure the feeling of human relation to nature stated in the opening lines of Thanatopsis:

> To him who in the love of Nature holds
> Communion with her visible forms, she speaks
> A various language; for his gayer hours
> She has a voice of gladness, and a smile
> And eloquence of beauty, and she glides
> Into his darker musings, with a mild
> And healing sympathy, that steals away
> Their sharpness, ere he is aware.

To one who really appreciates nature, the facts used by scientists only increase our reverence. Many years' study of earth history and of development of life have given me a philosophy of nature which some might almost call a religion. At the same time there has developed a deep sense of appreciation of the principles of harmony and unity which seem not to be avoided in any careful study of the natural world as we find it. I have often been interested in noting that primitive peoples, lacking our high degree of culture and our vast accumulation of facts, may look upon nature with a freer imagination, and perhaps a clearer appreciation of what it really means, than is often true of intensely civilized man. The stereotyped scientist or philosopher may see only his isolated facts; whereas the man whom we call savage may see the world as a whole, and realize that there is back of it something which he knows he does not fully understand.

One may not be surprised that Jefferson as a humanist was an intensive student of Indian languages. It is not generally known that he accumulated a vast amount of information on this subject. The loss of accumulated data was a sad feature of his later years. To the history of life in past ages Jefferson contributed one of the earliest publications in America, describing a strange, unknown creature from a cave in Virginia. Jefferson's scientific observations and philosophy were direct and exact. It was in some measure this ability to take the wider view, and use the most penetrating vision, that gave such extraordinary value to all his contributions. Jefferson's contact with nature and science crossed that of our great nature poet, William Cullen Bryant. At the early age of thirteen Bryant struck boldly at Jefferson's embargo on American shipping, as also at his scientific propensities, in a poem, in which, speaking of Jefferson, Bryant writes:

> Go, wretch, resign the presidential chair,
>
> . . . .
>
> Go, search, with curious eyes, for horned frogs,
> 'Mongst the wild wastes of Louisiana bogs;
> Or where Ohio rolls his turbid stream,
> Dig for huge bones, thy glory and thy theme

It may be that the influence of Jefferson in turning the attention of Bryant to science in his early years had importance. In later life Bryant's "Forest Hymn" presented one of the most interesting

of all American poetic statements on the development of nature in the words:

> My heart is awed within me when I think
>   Of the great miracle that still goes on
> In silence round me—the perpetual work
>   Of thy creation, finished, yet renewed
> Forever.

The number of books on this subject which one might read is large, but I prefer suggesting two or three of unusual value because of their human treatment. In general, history has suffered from failure to present such a view as gives appreciation of continuity and growth or movement. Breasted's "Ancient Times" is authoritative and humanly attractive. His recent publication on "The Dawn of Conscience" has an outlook of unusual significance to those who look upon man as constantly pressing forward to higher levels. H. G. Wells' little book of many years ago under the title "The Discovery of the Future" connects past and future in an exceptional way. Wells' "Outline of History" presents the story of mankind in such manner that one may not avoid thinking upon its meaning.

Assuming that great poetry is an artistic statement of great truths, one must believe that the deeper view of nature appearing through science will have much influence in literature of the future. There has naturally been a feeling that the tendency of science to tear the world to pieces for study has resulted, as stated by Wordsworth, in our

> Viewing all objects unremittingly
> In disconnection dead and spiritless;
> And still dividing, and dividing still,
> Break down all grandeur, ...

But science is now at the stage where the pieces are being put together, and in the light of modern knowledge the power and beauty of the natural world increase continually. The elements of inspiration, which seemed lost in analysis, return with fuller strength when the pieces are brought together again. And with this process the world becomes a more wonderful and a more beautiful place than it could ever have been without this intimate understanding. The poets will follow this development of thought.

In viewing the future of our country we are now taking stock of all

resources with expectation of better and higher uses for each. We shall find that science will show us many new ways of what Wordsworth described as "getting and spending." But, if for no other use than as a great resource in method, we should see that science is so developed as to give us better appreciation of all human values, even including the quality of mercy.

Again, as science touches everyday life we may not avoid recognizing the significance of nature both as teacher and as companion. In our attempt to go forward to what we believe are the more satisfactory methods of living, we may not forget that the appreciative relation to nature is one of our greatest assets. This has been stated by inspired writers through the ages: Goethe, Wordsworth, Bryant, and many others. Science will help to develop this relation in many ways. It will aid in demonstrating the need for great holy places, as in National Parks, where nature should remain exactly as the creator made it, and without intrusion of the handiwork of man. Here the visitor will worship, and act in accordance with the request, "Be still, and know that I am God." Also science, with aid of the Wordsworths and Shelleys of the future, will help us all to experience those joys which even the humblest flower that blows can give, each day and everywhere.

INTRODUCTORY NOTE TO "SAVE THE REDWOODS," BY JOHN MUIR

In his intimate acquaintance with nature John Muir recognized and loved everything that was natural and honest, but his interest focused upon the things which represented the most splendid expressions of creative power. Not only did he instinctively select for close personal companionship the elements of nature that had most to give for him, but, as no other western naturalist has done, he set forth their fullest meaning in the language of the people.

Of all Muir's special interests in nature, it is probable that none made to him a stronger appeal than the giant Sequoias of the Sierra and Coast Range forests. It was his firm conviction that they represented the supremest examples of majesty among all living things, and his journey around the earth to compare the Big Trees with the trees of the world left him with settled conviction regarding the correctness of this view. For many years he gave himself to the protection of these "Kings of the forest, the noblest of a noble race." At this time of national movement for the preservation of these forests through the Save-the-Redwoods League, it is particularly fitting that we present the sentiments written years ago, in support of just such a movement, by the friend who fought so hard, so faithfully, and so long in this good cause.

Sierra Club Bulletin, vol. 11, no. 1, p. 1, January 1920.

STATEMENT REGARDING BILL CONCERNING NATIONAL ARBORETUM

Mr. Chairman and gentlemen of the committee, all that I have to say relates directly to the problem of research. I recognize the importance of all that has been said with reference to the use of the arboretum for horticultural and other purposes, but concerning that aspect of the problem I am interested in the arboretum as a means of establishing a laboratory for the fundamental study of trees, and I am interested in the fundamental study of trees because, with those of you who have been concerned with the problem of forestry in the United States, I recognize that there is approaching, unless we watch it carefully, what may become an emergency; that is to say, the experts in forest trees are quite clear that some time between 35 and 50 years from now, unless we handle our resources with very great care, we shall approach a stage at which the great forests which have been among the greatest assets of America will be practically cleaned out as far as the major production timber is concerned, and we shall be faced with a situation in which we must use something other than trees, or we shall find ourselves lacking in materials for building and for other purposes to which wood has been directed in the past. That emergency, I hope, will not arrive, because I trust we are wise enough to make provision against the day when such a catastrophe will take place in this country.

However, there is no doubt that as we draw the lines, in other words, as we construct the curves to-day, the time is rapidly approaching when our wild forests, from which we draw so heavily, will diminish almost to nothing.

In the past the forests from which we have drawn our supplies of timber have been merely the mine or lode into which we have cut. The trees which we have used for timber purposes have been wild stock, and very little provision has been made for the replen-

Hearings before the Committee on Agriculture, House of Representatives, 69th Congress, 1st Session, on H. R. 3890, January 19, 1926, pp. 16–19. Washington: Government Printing Office, 1926.

ishing of the forest. Within a very short time in Europe, and to a certain extent in the United States, we have come to recognize that we must provide for new forests of a type something like those which we are now using for timber and for paper and for other purposes, but we have got to recognize that we are dealing in lumber and in the pulp industry solely with wild stock, whereas most of the plants with which we are concerned in general agricultural business are domesticated stock, and when we go back of the history of agriculture we find that the plants which we have under domestication are plants which came under domestication through a long process of contact of men with wild plants, and that they were picked up accidentally and nursed along for hundreds and thousands of years before we came to know their full value.

What has been done in the study of plants for human use is very much the same kind of process that the ancient Egyptians used when they wished to find out the best kind of building stone. If they wanted to know the material out of which to build a pyramid, they built a pyramid and allowed it to stand a sufficient length of time, and if the stone was good they used it for another pyramid. So in the working out of our program with reference to plants we have tried them out through tens of thousands of years to find out whether they fill our needs.

To-day, out of the vast number of plants known in the world, we are using very few. Some have assumed that these few which we use were plants that were preordained by the Creator for human use. There is no reason whatever for such assumption. The probability is that a very large percentage of the plants which are not used, under careful study might be as useful or more useful than those which have been brought under domestication. The difference between the situation to-day and that in past periods in which plants have been brought under domestication is that to-day man is reaching out into fields of knowledge which are called science, for the gathering of vast quantities of data or of information previously unknown. It is only a short time back to the period in which men thought that most of the knowledge that could be gotten about nature had been brought together. To-day we are at a stage when we recognize that most of the knowledge to be obtained about nature is still to be obtained, and that we have relatively little of what can be learned. I suppose that if there is

any fact with reference to science that stands out beyond all other facts at this moment in the history of the world, it is our recognition of the inadequacy of human knowledge and our recognition of the fact that most of what there is to be learned is still to be secured from study.

Now, research is the means by which we go out into nature to secure facts. Research to-day has carried us forward with strides which we have not known in any past period. This is particularly clear, I presume, in the field of physical science. When we have such discoveries as electricity, the radio, the X-ray, and the new rays that come from space, we wake up suddenly to the fact that there are vast fields of knowledge, of which we have not had a glimmering of a suggestion as to what they mean. In the field of biology, we are still to a certain extent in that stage in which we feel we know the greater part of what there is to be known. Let me make only this comment, that the field of biology probably contains more facts unknown than has been true of the field of the physical sciences. But it has been easier to get into the field of physical sciences than into the field of biology, because biology is much more complicated, and, to us, a much more important subject, so that I want to say that to-day we are facing a time when we are likely to receive, in the near future, a vast bulk of new information relative to animals and plants.

As far as that applies to the problem of the arboretum, what I have to say is this: We are to-day dealing, as far as trees are concerned, with wild stock. We know that we have relatively little information about trees all the way from the study of their structure and their physiology and their variation, etc. We know that there is a vast stock of information to be obtained. We know that we are approaching what may be an emergency within practically a generation. We know that in emergencies people do not dig down into the foundations of knowledge and drag out facts which are needed. One of the great lessons of the war was that you can not develop fundamental research on the spur of the moment. Necessity may be the mother of invention, but necessity does not develop new fields of knowledge. One of the things which we learned in the war and which ought to be blazoned all over the temples of knowledge is that in an emergency the thing to do is to use the fundamental knowledge that you have, to best advantage, and not

stop to go into the fundamental investigation which requires decades and sometimes generations to carry it through to a stage at which your knowledge becomes useful.

To state the facts again, we are facing an emergency. We know that there is a vast amount of information to be obtained. We know that fundamental research takes time. We are just at the proper point to-day to begin the kind of investigation that is needed in order to meet the critical situation which will arise within a generation, as far as forests are concerned.

Now, the Department of Agriculture is a tremendously effective instrument assisting this country to better its condition from year to year. The Department of Agriculture has done a very great work and is doing a very great work in the study of plants and in the study of trees. There is in the Government and in the city of Washington one of the greatest groups of scientific men that we know anywhere in the world, effective people, interested, honest, patriotic men, and they are doing all in their power to meet this thing which we see coming. One of the instruments which they need for utilization in their studies is a laboratory which will not be a place in which to keep dried specimens or keep chemicals, but a laboratory in which you will have a living plant and a living tree, where it can be studied under most favorable conditions from year to year, decade to decade, and from generation to generation.

I support the arboretum bill because it is a means toward this very fundamental purpose, to serve the needs of mankind of the future, and a laboratory in which the biologist can conduct investigations under most favorable conditions.

I support this bill not because Washington is the only place in the world to have such a laboratory but because in the first place it is a point at which the greatest group of scientific men is brought together, and it is, in the second place, extremely fortunately situated, in that it represents the overlapping of the northern and southern region, a place in which, while you can not grow all the plants that are found in the world, you can grow a relatively large number of kinds under very favorable conditions.

A remark was made that I am a member of the National Academy of Sciences, of the committee on forestry. That committee on forestry, in the course of the past two years, with the cooperation of the Department of Agriculture, has been planning a study of

certain very fundamental kinds of investigation basic to forestry. Recently the National Academy of Sciences appointed a small committee of very able men to make certain of those studies, and we have financed those investigations; but those investigations are of quite a different type from those which would be carried out by the use of this arboretum. They are investigations of a temporary character to furnish data for the future, not investigations such as would be carried through by the use of this arboretum. I sincerely hope that this bill will meet with your favorable action.

WHAT SCIENCE CAN DO FOR FORESTRY

My interest in forestry is twofold. It concerns something that I do not explain, an interest in trees and in forests, and also an interest in the application of fundamental research to the problems in this great field of industry. I ought to make it clear to you that I am not in any sense a specialist on any phase of the subject you are discussing. My only right to address you is, I presume, that I have been concerned with the organization of scientific research. Looking at this problem in the broadest possible way, I believe there is and will be an opportunity for the application of the principles that are being derived from these studies.

Please bear with me, as a person academic in a sense, talking to you, a group of practical business men, not so much upon questions of immediate importance as upon the things of the somewhat distant future. But I have never yet found that a group of business men concerned with large problems look only upon the present. Big business must involve the future. The men who are concerned with problems of the forest see farther into the future than most groups concerned with industry.

My first point concerns a very broad consideration of the relation between science and industry. I look upon science from the viewpoint of common sense, yet realize that science in any organization attempts to reach out beyond ordinary experience, to bring in knowledge of the law of nature not previously available.

The relation between research and industry is undoubtedly best shown at present in the contact of physical science with industry that touches power or mechanical organization. Fifty or seventy-five years ago the gap between science and industry was very wide. In my college professor days it was our custom to state that the application of the physical principle, which was the plaything of the professor in his laboratory, was to be expected in the next or in the second generation. Today that gap has been so nearly bridged that

Address before the Conference on Commercial Forestry, Chicago, November 16, 1927. *Report of the Conference on Commercial Forestry*, pp. 167–173. Washington: Natural Resources Production Department, Chamber of Commerce of the United States, February 1928.

the new facts which come from the study of the investigator in the physical and chemical laboratory go almost immediately into the stream of use.

The relation is such that the great physical industry not only looks for these facts, but recognizes them as a part of what it capitalizes, and it deliberately organizes great laboratories in which it participates, not only in the application of knowledge as it appears, but in the development of new information. Today the laboratories of certain of the great industries, General Electric and the companies related, telephone and telegraph, are among the greatest agencies in the world for the extension of knowledge. Not only is that the case, but the value of the underlying securities of many of these great organizations has its 100 per cent value because we know they are in touch with the development of science and are, therefore, in a position not only to grow, but to protect themselves against any possible discovery that might seem to invalidate their method of approach or utilization.

A stage, then, has been reached in which, in the chemical and physical industries, the stream of new information goes at once, or almost at once, into use. The development of these industries rests in large measure upon the progress of knowledge in the most fundamental sense.

Perhaps I might refer to the fact that the great industries concerned with the problems of physical power are so much interested in the investigations of agencies concerned with these subjects that they wait eagerly and are ready instantly to take and to use the results, for example, that come from the Carnegie Institute's observatory at Mount Wilson, California.

On the other hand, the aspects of science and the industries that relate to life, including the whole range of agriculture, forestry and the lumber industry within that, are in quite a different situation relative to the contact between the investigator and the applier of knowledge.

The life sciences—botany, forestry, zoology, anthropology and human behavior—are based upon fundamental laws, in which the basic principles are physics and chemistry piled together in such a way they make a complex we can't quite understand. Yet we know those sciences are subject to development in the law sense just as are the laws of physics and chemistry in the physical industry.

In the ordinary life process of a plant or tree, one of the fundamental things with which you and scientists are concerned is the problem of what we call photosynthesis, or the effect of light in the growing process of the plant.

In the Carnegie Institute we have one laboratory devoted entirely to this subject. We have a small group of men, the ablest men to be obtained. They have been studying the world situation of research in photosynthesis. They know there is chlorophyll, a green substance, in the plant. They know that light comes in, that certain simple chemical elements are there, and from that contact or that combination there arise the things that make much importance in the chemical and life products of the plant. What happens we do not know as yet. We know the process is one that is called catalysis, in which a small amount of a certain substance takes up these other things, molds them and sends them on their way. We have located some of the catalyzing agents. We have investigated their chemical composition.

I am sincerely hoping that within my lifetime we may make some of the next stages; maybe we shall not. If we do discover what happens, we shall not only have one of the most fundamental of all the things that possibly could be learned about the plant, but we might be able to take the same process and set it up for operation somewhere in the laboratory. At any rate, we see here is a great field, one of the greatest in the whole range of science, and if this problem could be solved we would be in position to do a lot of things that forestry wants to do at this moment. The point I am making just now is that biology, the life sciences, botany, agriculture, forestry, represent so complicated a group of interests that the gap between the investigator and the applier is relatively wide.

Turning to the situation in forestry and its relation to research: it is not my business to attempt to classify your activities, but from my own point of view it is necessary to do so or I might go astray. As I see your activities they relate to three things: first, your protection of what you have; you protect against fire; you protect against insects; you protect against plant pests of one sort or another. Last of all you protect it against yourselves, that is against those difficult, economic situations which might make it difficult for you to hold the property that you own because of situations that concern taxation and so forth. In other words, the protection of what you have is one of your great functions.

The second is the utilization. Of course, that is what it is for. How shall it be applied? How shall trees be harvested? To what purposes shall the materials be put? What are the economic relations which you must develop in order to put the material into the largest, fullest and best use?

In connection with that you have the very legitimate and necessary study of how this may be done so as to be profitable. If it isn't profitable, no one is going to do it. Even if the community does it as a whole it isn't profitable. By the way, I am one of those who believe in government by cooperation and understanding rather than by the imposition of law through what we call law enforcement; in other words, government by agreement rather than government by legislation.

The third point in your industry is that you are concerned with the further development—that is, the coming crop. I realize that up to the present time forestry has been based on a mode of operation in which you have harvested large quantities of materials which lay open to your hand, because the supply was abundant. The operation, in some measure, has been like the harvesting of the materials from a mine, without particular consideration, in some instances, of what is to come, excepting that the land may be used for some other purpose. We know perfectly well that that cannot continue indefinitely. Forests may grow to some extent, where they are cut, and sometimes very good ones, but, in general, when you destroy a forest, not merely the trees but the association of things that go with it, it is difficult to reestablish that situation. I know perfectly well, although you may have harvested these things in the sense of a crop that was to be taken, and the land left, you are at least as altruistic as other people, although you are said by tree lovers to leave a trail of desolation across the continent. I don't think anyone who lives in a wooden house has a right to say that. You might say that people who live in wooden houses should not throw stones, as well as those who live in glass houses. I know you are as altruistic as other people; I know you are as farsighted. In the course of time, when the emergency begins to arise you will meet it. I have no feeling that the great calamity of wiping out the forest is ever going to occur. You are going to meet that in a way which will give to society the same kind of a crop that it has had, or a better one, in the future. Your further crop, while it has not been up to

the present time so important as other aspects of the work, is going to be one of the great and important features.

With relation to the contact of science between forestry and the lumber industry in these three points, first with reference to protection: you are protected from fire, in a large measure, by principles which come out of the development of the physical sciences, by better organization and by common sense, in which we get a better human adjustment. If you could discover some sort of a self-extinguishing cigarette or eliminate from society the careless people, you would make great advance. Neither of these things is likely to happen.

On the utilization you also have a vast support from the direct and the immediate application of physics and chemistry, in the study of the types of material and their utilization, and you can bring into the stream of forestry, almost as rapidly, the results from these fields of physical sciences as the results flow into the great physical industry.

On the third point—that is, the question of the future crop—you will pardon me if I return, in a sense, to the point of view which I naturally take. It was a great kindness that the chairman didn't introduce me as a fossil man. At one time I was concerned with the study of fossils. It is with great kindness that I look back to the past. I will admit it and say that a good part of my training has been training in the study of the sweep of things through time in order to get a better understanding of what is coming in the future. When I look at a problem, at the development of an industry of this sort, the first thing I do is to watch the trend of it, and what is the expectation? The expectation is, unless we consider it, the new crop problem will ultimately be in difficulty. You would do it as quickly as I would from my point of view.

When we begin to consider the problem of the further crop, that is where our troubles arise, because, in the first instance, we know relatively little about the tree. I am not disparaging the work of the investigators in all fields, botany and forestry. I have sat too often, in the course of the last year, with leading experts, men who know more than others in the world, about the structure of the tree, to feel that we know much about it. Last summer I sat with three men, the ablest ones we have been able to find in the United States, who had before them the extremely simple problem of finding out

how sap moves in a tree. I supposed they knew all about it. I remember giving a lecture on this to a group of students in a high school where I was talking in 1887. I remember drawing the diagram of the tree. These three men felt they knew, but a fourth man came in and said, "Here is a line of attack you haven't followed." They followed it. They got a morphologist, a man who studies the structure of the tree, and two physiologists. They attempted to trace out the sap. They found, contrary to all textbooks, the sap didn't run where it was supposed to run; it wandered all around inside the tree. They found living cells in redwood trees that were 100 years old. They found it wasn't going according to schedule. They wondered what happened in the younger tree. They found, under pressure, it had something to do with the life process.

They sat down and said, "This is a nice thing for three distinguished men to be telling to the president of the Carnegie Institute, who has been working all these years."

I said, "It is much more important to discover you are wrong and rectify that situation than it is to go on indefinitely."

This is only one point, a very superficial thing in the study of the tree, how the sap moves. We know something about it, but relatively little in the fundamentals. I spoke a moment ago about photosynthesis, or what happens in the green leaf. We are still worse off when it comes to that. When it comes to the study of the forest as a whole, we are again in an extremely difficult situation. A forest does not consist of so many trees standing side by side; a forest consists of groups of trees with many associated plants, in many instances with many insects and parasites. It consists of the soil out of which the plants grow, the soil bacteria or flora. It consists of the relation to a large number of extremely important and complicated chemical and physical reactions, and not until you have seen all of these have you known the forest. You can't wipe out a forest and put it back until you at least know something about what the forest is like.

In the United States we have a tremendous responsibility today. The spirit of science is penetrating through forestry and botany and the lumber industry everywhere. We have an opportunity to begin the study of the forest as it was, through the hundreds of millions of years in which it has been built. We have the opportunity to

know how it came to be, and what its present relation to its environment is. We have the opportunity to get that information and then to go on into a study of the basic problems of photosynthesis, and so forth, and construct a scheme comparable to that which the physicist has before him when he begins to study the nature of matter.

I pointed out that you have got one of the most difficult problems in the world. Trees are long-lived. We haven't paid much attention to them. On the other hand, it isn't cluttered up with difficult things such as have arisen in many other sciences. You are in a position to take up the study of this problem. Your attitude is the finest attitude I know, and I expect to see the culmination of your work lead to putting biology in its relation to forestry on a sound basis, so through the coming generations the problem is going to solve itself gradually.

You say, "That is all very nice for the next generation. How about the present?"

I am only going to make one comment. The greatest single law I know, that has ever come out of science, is the law which expresses the idea that the universe of life is a developing thing, changes from age to age and changes toward the development on higher levels, that includes man and the life about him. That is a progressive scheme. The most important thing in that progressive scheme, from my point of view, is the fact that the human being has a chance to fit himself into a great scheme that begins in the past, which we can't see, and goes on into the future; and that everything you do today that is of a constructive type is going to bear dividends through to the end of time.

Men think they work for a living. As a matter of fact, they work because of the desire of accomplishment. You are not concerned whether you do get your result at this minute here or outside the building, in San Francisco or England. You are not concerned whether you get it today, tomorrow, or next year. You want to be recognized as constructive individuals, and that is right. I believe in it. If you fit yourself into this program, you are going to help to build a very great foundation for future civilization.

Last of all, I have never known of a constructive movement in the history of the world that capitalized the future that didn't get its reaction in the present in credit and materials. If you go to

buy bonds, the longer term your bonds run, even with an even rate of interest, the greater the likelihood of your having a relatively high price.

If you capitalize the future and indicate your land is at some time going to be more valuable, that value gradually creeps back into today. You will find with the joy of your altruism and your building you are going to give support to a great movement which will help you at this minute.

My last point is, support fundamental research and its application. Support the work being done by the federal government and the forest service—a great group of men under a great leader. I think Colonel Greeley might have been a good geologist if he had continued with geology, but he went into forestry. He has a great group of men under him. Support the work in the state; support the work in the private institutions. It will bring you returns. I cannot give you all the facts to prove it, but I guarantee it will.

PRESERVATION OF THE SEQUOIA FORESTS

EDITOR'S NOTE.—As a scientist, as an executive, and as a writer, the name of Dr. Merriam is known throughout the country. His unselfish service, with other California leaders, in the Save-the-Redwoods League has resulted in preserving some of the finest stands of redwoods in northern California. His prophetic suggestion is much in point.

THE movement to preserve the sequoia forests, although centered in California, has represented the concentrated effort of interested citizens of the whole country. It has been, in many respects, one of the most interesting conservation movements in America. The exceptional success of this activity is due in considerable measure to the fact that it has been held to a limited objective. It has been carried out on the basis of high ideals, and through the medium of wide-ranging coöperation representing practically every type of organization interested in outdoor life, the study of the tree, and inspirational influence of the forest.

Initiated for the purpose of bringing at least a few groves of north coast redwoods into the possession of the public, the movement extended itself to cover a broad study of the significance of the sequoia in all forms of use, from practical economic utilization to inspirational influence. The program has involved careful regional studies of large areas of the State in which redwood forests are located. This work has been done by leading experts and has been carried out with the purpose of defining plans by which these forests can be given an effective setting with relation to other parks, to the highway system, and to localities of unusual recreational value—a very different procedure from that resulting in some instances from sentimental reasons.

Although the effort of the Save-the-Redwoods League has directed itself mainly toward saving coast redwoods, there has been no lack of interest or purpose relative to protection of the giant sequoia of the Sierra region. At the time of initiation of this move-

American Civic Annual, pp. 116–117, 1929.

ment, the giant trees had relatively larger chance for protection, and the movement therefore turned itself toward saving some of the magnificent forests in the coast redwood region. The continuing work of the Save-the-Redwoods League has involved in its purposes the saving of larger areas of giant sequoias.

Beginning with a situation in which no provision was made for protection of the northern coast forests, the Save-the-Redwoods movement resulted in the purchase of considerable groves and many beautiful stretches of redwood forest by the State and by private contribution. Careful development of some of the areas already obtained shows the tremendous value of these assets to the whole people of the United States. Treatment of the larger areas in such manner as to preserve their primitive character will ultimately make it clear that these forests are among the most interesting natural features in America. Among living things there is probably no more impressive spectacle than that presented by a sequoia forest.

In addition to progress made in preservation of redwood forests by the League organized for this purpose, it is important to note that through the influence of this organization there has arisen one of the most interesting movements in America for participation of a State in acquiring, protecting, and utilizing natural areas for the benefit of the people. The efforts of a group of tireless workers, represented by Mr. Duncan McDuffie, Mr. W. E. Colby, Mr. Newton B. Drury, and others in California, have brought into being the new State Park organization, which is constructing a program of extraordinary importance in securing and developing resources valuable for their natural beauty, and for the opportunities they offer for outdoor life. History may sometime show that, in drawing attention to the need for its protection, the redwood has exerted an influence through the whole field of American conservation.

It would be a great disaster if the ancient redwoods of California were to be completely destroyed. But there is also tragedy involved in the destruction of other fine, characteristic trees, standing in their native groves. Every State in the Union should be searching for whatever remains of primeval forest or plant life, in order to preserve and cherish for future generations samples of the State land as the pioneers found it.

Photograph, Colored in Oil, Copyright by Fred H. Kiser, Los Angeles

View of Crater Lake from South Rim

CRATER LAKE

A STUDY IN APPRECIATION OF NATURE

In an attempt to determine how regions of exceptional beauty can be made most satisfying to visitors, a study of Crater Lake National Park, in Oregon, has been carried out in cooperation with the National Park Service of the Department of the Interior. As a part of the problem it was necessary to formulate a grouping of features or qualities comprised in what we call appreciation of nature. The tentative results of this study are presented here as basis for later discussion.

The influence which present-day mechanical civilization exerts upon us has become so large that we tend to discuss problems of our surroundings mainly in terms of relation to the human environment. But we may not forget that through most of the vast stretch of history nature has been a dominating factor in shaping both our activities and our ideas. Even at a time when the high degree of unity in organization of cities begins to impress us as suggesting great organisms, we can not avoid recognizing that man is still immersed in a world of nature, and that the influence of this external world upon him is one of the greatest factors in everyday life.

As we consider nature in practical life it is common to define it in terms of what we may obtain from natural resources like coal and iron, products of the soil, and whatever contributes material which can be used or shaped. We take for granted the light, heat, and other influences from the sun which make life possible. We accept in the same way the oxygen of the air, vagaries of the weather, and the play of light giving reality to infinitely varying aspects of beauty in the outer world.

In pioneer days we struggled with obstacles of nature—rocks and trees which cumbered the ground, streams difficult to ford. We gloried in conquest of the wilderness and the dominance of man over nature. Now that natural resources have been parcelled out

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in various types of ownership, forests have been swept from our path, deserts traversed, and practically nothing remains inaccessible or unconquered, human kind begins to consider the significance of nature in relation to the intellectual, aesthetic, and spiritual values of life.

For the vast majority of human beings nature exerts a very large influence upon the emotional aspects even of life as lived from day to day. Such imprint may be made by the glory of the sky, sublime expression of power in the ocean, or the subtle influence of changes in beauty of the landscape with passing seasons. This feeling of man toward nature as influenced by its varying moods is what we sometimes call appreciation of nature. Along with the infinite variety of specialized human activities or artificial situations, it constitutes one of the principal elements of interest and pleasure in life. Its significance for the future seems not destined to diminish. To obtain an understanding of these values which would make possible their highest use in human service would be a work of exceptional importance. Such a study might involve the whole range of nature, from the most spectacular phenomena of mountain and forest to quiet beauty of meadows, and to the humanly controlled or domesticated features of nature that appear in the simple green plant, or the bright flower in a tiny back yard.

In study of the Crater Lake region there has been practically unanimous agreement that beauty is the dominating feature. Other elements have been considered as grouping themselves around the aesthetic values. The possibility of aid to visitors desiring to understand this picture has made necessary examination of the lake and its setting, in the light of what seem to be the major elements represented in appreciation of nature.

For purposes of such a study, an attempt to separate or classify the elements comprised in nature appreciation indicates that in one phase it represents only subjective influences related to what we see. This may be expressed through the whole gamut of human interests and reactions, ranging from what seems purely physical on through the aesthetic, intellectual, scientific, philosophic, and religious. It may be based upon relation to personal experience, or on something arising from the cultural history of our ancestors.

The physical aspect of our reaction to nature is not unimportant. Natural conditions suggesting absence of purely social restraints,

with the right to grow in our own way, are commonly a stimulus to development of physical freedom and action. This influence has been important in origin of that larger freedom upon which, in some measure, political independence rests.

The infinite combination of pleasing sense impressions in color, form, pattern, sound, and the symmetries or harmonies which they make, leads us into the path of emotional reaction represented by the aesthetic. We consider not merely how we see nature in terms of light, form, and pattern, but examine it in terms of how we feel about it in the emotional sense. It is also important to remember that emotion may rest on intellectual experience as well as upon other materials.

Influence of the impact of nature by that endless series of mysteries presented in its force and action has advanced intellectual inquiry through development of science and philosophy. With the growth of science, understanding of nature extends over widening fields. As this vision opens we see the emotional reaction to the intellectual stimulus building itself to higher levels.

The study of how natural features appeal to us presents unusually significant questions at Crater Lake, as with many exceptional aspects of nature represented, interest seems at first glance to focus on one thing above all others. Attention appears to turn immediately toward the lake, a thing of rare beauty resting in the circular crater of a great volcano.

With all of the interest attaching to very many features in the extraordinary crater, to the picture of wide regions spread before one, to beauty of forests and the flora of mountain meadows, practically every one is attracted instantly by the compelling charm of the lake. Impressive displays of color may be found in every region of the world, and blue water is a familiar sight. In this particular lake interest is drawn and held by an expanse of blue not exceeded in intensity or brilliance by other lakes or seas, and by its contrast with a landscape especially fitted to emphasize these charms.

The water changes from moment to moment. Shifting air ruffles its surface in numberless ways, altering both color and rhythm of movement. Local wind-flurries sweep across the basin stirring the waves as if by the discharge of countless jets of air, each producing a sharply defined path along the course. Brilliant green

patches about the margins present contrasts which strengthen impression of the broad expanse of blue. Changing clouds mottle the surface with their shadows. The moving sun develops varying reflections from surrounding cliffs.

Perhaps above all other influences which tend to increase values of the scene are the steep crater walls bordering the lake, centering attention upon the water and furnishing striking contrast by a frame which limits and defines the charms of this picture.

Relation to varied aspects of beauty in the lake gives added value to many elements in the surroundings. Mountain hemlocks grouped along the crater rim are in themselves things of unusual charm, but projected against the lake or serving as bordering elements of vistas looking down toward the blue water, they acquire added significance, and accent sharply the color of the lake. Cliffs of brown and yellow volcanic deposits around the water might draw attention without their present setting, but in contrast with the great expanse of blue they have increased power to attract.

So in an almost infinite variety of ways features associated with the lake have added meaning by this contact, and each of these situations changes with hour of the day and day of the year.

Just as no one who comes to the lake fails to be thrilled by its beauty, so there are probably few who do not raise question as to the striking setting of the picture. How can one account for a wide, deep, clear lake in the summit of a mountain? There is no entering stream, no outlet. Excepting the steep surrounding crater walls, the summit falls away sharply in every direction. What relation can there be between this strangely beautiful water and the unusual mountain?

The answers obtained by every keen observer may be supplemented by observation of those who have spent years in study of similar questions. To one not learned in characters of volcanic rocks it might be possible to mistake some other kind of depression on a mountain for a crater. But careful workers in the region find all of the rocks in the walls to be types formed only from molten material, like that at nearby volcanoes such as Mount Lassen or Shasta.

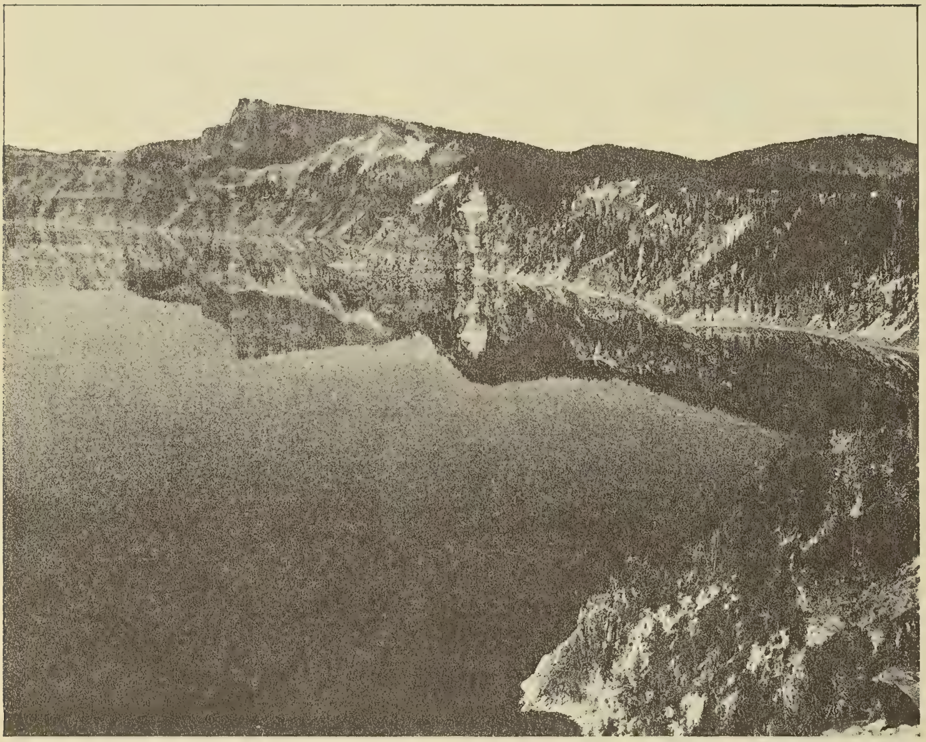
We know also that not only the mountain at Crater Lake, but a vast surrounding region, perhaps two hundred thousand square miles in area, is of a type indicating tremendous outpourings of

Courtesy of Sawyer Scenic Photos, Inc.

Crater Lake, looking north toward Wizard Island

Courtesy of National Park Service

View of South Rim of Crater Lake, with Dutton Cliff and the small island known as Phantom Ship



Courtesy of National Park Service

Crater Lake, view toward Llao Rock on the North Rim, with strong cliff reflections

lava. In the midst of this great region of volcanic activity the mountain at Crater Lake stands as an exceptional feature in its structure and history, as well as with respect to its peculiar beauty.

The eyes of any interested observer find the walls surrounding the lake formed by layer upon layer of lava, volcanic ash, wash of streams, and other materials deposited under varying conditions. No one who sees these built up sections of the wall can doubt that year upon year, or age upon age, it was growing from a low elevation to a mountain. Here and there in the ashes are buried stems of trees caught in the heated mass and turned to charcoal, just as happens about volcanoes today, or as we see such charcoal residues of wood buried in the ruins at Herculaneum. The mountain side is penetrated at several places by solid lavas that in some earlier period oozed out through breaks or fissures in the wall and then solidified. How long this building process lasted has yet to be determined, but it was a time of many changes and perhaps of long duration.

The great crater or bowl that rests in the top of the mountain seems, like the forming of the mountain itself, to have had a long history of shaping. The summit existed in a sense because there was an opening through which the volcano released products from its activity. The vent changed from time to time according to variation in the forces from which the mountain resulted.

Everywhere about the inner face of the crater wall the edges of layers forming the rim seen to give evidence of recent breaking away to widen the opening. Observations of the scientist have yet to show whether this was brought about through blowing away of the top or by falling in of walls. By one process or another, or perhaps by several ways combined, as the mountain grew, the crater's opening enlarged, until there had come to be this combination of a great mountain with the deep crater five miles in diameter at its summit.

Though we may not know details in the process of forming the mountain, the broad outlines can be appreciated to such an extent as to give answer to questions concerning relation of lake to mountain. Near the end of one of the most important known periods of volcanic activity expressed in the region of the northwest, this mass was built by the long series of events described. Each stage was a spectacular expression of the power and energy translated

into movement and heat of the volcano. Forming the present bowl of the crater was a process involving tremendous forces, such as human kind has only partly appreciated.

Sometimes the mountain was a quiescent region of forest and flower-strewn meadows, where swift streams were slowly washing its bulk away. At other stages it was the home of snow fields and glaciers, and again it became the scene of lava outpouring with intervening showers of ashes burying the landscape. And when it had been modeled through long action by agencies among the most powerful that man encounters, preparation was completed for a lake, such as now exists. By no other known method could this peculiar setting have been furnished. It remained then only to have given, at this spot, such climatic conditions with fall of rain and snow, as now obtain—adequate to accumulate a body of water in the crater without filling it, and yet with seepage such as would maintain its marvellous clearness and purity.

Just as all who see the lake come under the spell of its beauty, so there are few for whom the story of its coming to be does not take on increasing importance as acquaintance grows. The sublimity, power, and orderly operation expressed in this process of creation develop in us a sense of appreciation corresponding to influence of reactions produced by other elements which we recognize as beauty and harmony.

To one who views the whole range of features having special interest in this grouping about the lake the close relation among them is itself impressive. It becomes clear that what nature means to us involves a multitude of things, each in its way influencing our sense of appreciation. And equally important is it that the aesthetic, the sublime, orderly activity, and development or growth, along with those intimate interests that touch our personal life, become most significant when woven into a pattern in which unity is a dominating element.

INFLUENCE OF SCIENCE UPON APPRECIATION OF NATURE

CELEBRATING the one hundredth anniversary of a division of science and a great state museum inevitably directs attention toward changes or progress registered. Ideas derived from this study may be applied in many directions, but, following the lines of my own relation to these activities, I have chosen to talk on the influence which science exerts upon our cultural and spiritual view of nature. One reason for this choice is that at the moment there seems to be relatively little interest in formulation of ideas on this subject, in spite of the fact that we are practically embedded in the world of nature.

Over the ages, influence of nature upon man and appreciation of nature have been among the most important elements in life. Great advances of science in modern times having enabled us to reach far beyond the range of vision and understanding previously possible, one might expect that appreciation of nature would increase in importance and in its contribution to our satisfaction. But so varied are the present-day appraisals of value in nature appreciation that it has seemed worth while to examine the subject on an occasion such as this, when consideration is given to advance of science in close relation to cultural progress over a period of many decades.

Modern developments in nature study, acquisition of natural parks, and the featuring of conservation might be assumed to indicate that appreciation of the world about us has a place of exceptional importance in life today. But we find recent students of the nature problem like J. W. Beach stating that in certain literature earth and the stars are now regarded as scenery or setting; and

"The One Hundredth Anniversary of the Establishment of the Division of Science and State Museum—Proceedings of the Seventy-third Convocation of the University of the State of New York," *University of the State of New York Bulletin*, 1938, *No. 1143*, pp. 11–21, July 1, (date of publication, November 14, 1938). *Carnegie Institution of Washington Supplementary Publications*, no. 44. 11 pp. November ,21 1938.

that to some extent "The present-day poets have given up nature, having found it bankrupt." In various directions there is evidence that modern life tends to center its interest upon those aspects of development or evolution which relate to man's creative activity, along with his remodeling and mechanizing of the world.

The extent to which civilized man has advanced in appreciation or love of nature it would be difficult to measure. Doubt is sometimes expressed whether, in his attitude toward the natural world, cultured man of today has advanced much beyond the stage of his ancestors in remote ages.

With these views concerning man's relation to his natural environment there has come questioning as to the human value of appreciation or love of nature. It appears that in some aspects of literature, such as poetry, the nature concept has lost the place which it once held, and that the elements which were humanly so satisfying have in large measure vanished. Among the suggestions relating to this situation one finds the idea that rapid development of science in tearing apart or analyzing of elements in nature has tended to destroy the values formerly so important to us.

Recognizing what appears to be failure in ultra-modern literature, and in some measure in modern art, to attain the levels of nature appreciation of earlier periods, and noting also the tendency to emphasize achievement in man's creative work, I approach this discussion with the purpose of considering whether appreciation of nature may not maintain its place of high human value just by reason of the contribution from science rather than in spite of it. May we not expect that widening and deepening the vision of nature will bring us to points of view where new glories can be glimpsed, and even more satisfying relations established?

Although Wordsworth, perhaps the greatest student of nature appreciation, did not approach this subject directly by way of science, it is interesting to note that he distinguished between values of nature *impressed upon us* and those developed *by study or contemplation.* In his Tintern Abbey poem of 1798 he contrasts his earlier impressions of nature with those of later years in the words:

> "The sounding cataract
> Haunted me like a passion: the tall rock,
> The mountain and the deep and gloomy wood,
> Their colors and their forms, were then to me
> An appetite; a feeling and a love,

That had no need of a remoter charm,[1]
By thought supplied, nor any interest
Unborrowed from the eye.—That time is past,

. . . . And I have felt
A presence that disturbs me with the joy
Of elevated thoughts; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean and the living air,
And the blue sky, and in the mind of man:
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things."

If my point of view is as clearly correct for others, as it has proved itself for me through the years, a great responsibility rests upon those who follow the progress of science to see that we grow in the joy of appreciation of nature as knowledge advances. My special application of this subject to the situation presented by the centenary celebrated here derives from the fact that precisely the needed relation between the drive of factual research and its expression through cultural, artistic, philosophic, and religious interpretation has been exemplified by the institutions in honor of which we gather today.

Nothing that is said regarding advance in appreciation of nature through the contribution of science should be assumed to suggest lowering of values impressed upon us by nature through the senses, or such as might be expressed in color, line, pattern, balance or the many forms of art. These values, and others that belong in the types of imprint from nature, will have continuing significance, which should increase rather than diminish, and must furnish a large part of all that we derive from nature.

It is, perhaps, desirable to repeat the statement that, with rapid development of interest in man's creative activities and in the mechanized features to which so much of modern life is given, the trend of many interests may sweep along with the mechanical aspects of human creation, appearing to leave less of thought devoted to the contribution of nature. But even under such circumstances the whole relation to nature, including the more distinctly sensuous imprint, might be maintained and developed on a continu-

[1] Italics by author of this paper.

ing basis by reason of the appearance of new values in nature arising out of science: values coming from springs of constructive thought which are at the same time the source of those contributions which lead ultimately to human creative work.

Examination of the relation between science and nature appreciation inevitably reaches a point at which it becomes necessary to consider the meaning of such terms as appreciation and natural beauty. Difficulties of the case are exemplified in a measure by difference of opinion which arises in distinction between beauty and sublimity as applied to consideration of what is appreciated in nature. In the category of things beautiful some have included what is recognized by others as the sublime. Some have excluded the element of sublimity and include in appreciation or love of nature only that which falls within narrower limits of beauty in the aesthetic sense.

The relation between appreciation of nature commonly recognized as aesthetic and that based upon scientific knowledge is illustrated in many interesting ways in study of regions such as the Grand Canyon of the Colorado, to be mentioned more specifically later.

Commonly what we call love of nature or appreciation of nature comprises many factors of quite different types. This relationship may express itself through the gamut of human interests and reactions, ranging from what seem purely physical activities on through the aesthetic, intellectual, scientific, philosophic and religious. It may be based upon influence of purely personal experience, or upon something arising from the cultural history of our ancestors.

The infinite combination of pleasing sense impressions derived from nature through color, form, pattern, sound and the symmetries or harmonies which they form, has led us into the path of emotional development represented by the aesthetic in many combinations. In appreciation of the beautiful one thinks immediately of pictorial art as representing nature. So also, we recognize that harmony of forms upon which architecture is based.

The impact or stimulus of nature given through the endless series of mysteries presented by action of the forces about us has advanced intellectual inquiry through development of science and philosophy. With the growth of science, understanding of the natural world extends to deeper reaches and over a widening field. In corresponding measure we see the emotional reaction to the intellectual stimulus from nature building itself to new levels.

Appreciation of nature lies then in this wide group of interests, with their combined physical, intellectual and emotional appeal. It may be limited to one thing; or it may be all combined.

The mission of those who have sought the sources of human value in contemplation of nature represents one of the great quests of all time. Success in directing attention to these springs of interest, stimulus, and comfort, or in defining them, would mean making more fully available to the world some of the ways in which to enjoy life and to "glorify God" while life is lived. Search for means of expression adequately representing these elements of value in nature has interested nearly every group of workers concerned with formulation of great human problems. Painter, poet, philosopher, scientist, theologian, have all busied themselves with these questions.

Among artists, in the study of nature appreciation painter and landscape architect have made great contributions, but the poet has perhaps reached farthest in expressing the features present.

As the study of this problem advances it seems clear that to limit art merely to the pictorial, to color, form and similar aspects of representation, does not define its mission adequately. Rather may one say that the art of those who study nature should not be set off in closed fields separate from science and other subjects. It is a mode of expression which may be utilized to present, perhaps in the most realistic, and most highly imaginative, and most humanly appealing form, the results derived from all kinds of approach to nature.

It is important to note that the great cultural and spiritual value of outstanding phenomena in nature does not lie merely in their influence for the moment. It may concern things of the day alone, but it relates also to what might be called permanent reorganization of the mind in such manner as to give new views of the universe and of our place in it. In nature, as in other relations, we appreciate the meaning of Keats's statement in the opening lines of Endymion:

> "A thing of beauty is a joy for ever:
> Its loveliness increases; it will never
> Pass into nothingness; . . ."

In discussion of these problems there arise inevitably questions concerning the place which science may hold in relation to contribu-

tions by art to interpretation of nature. In general we can understand that while the scientist walks with reverent feet when treading paths broken by the humanist, there is often a possibility that the wonder and charm revealed by investigation may present aspects of nature corresponding in significance to those which have been the objective of interest and creative work of humanists such as painter and poet. And, since the scientist is always seeking new light on the unity of knowledge, it might be unscientific not to attempt an understanding of such situations.

From the point of view of the scientist, in our relation to nature there has appeared no lack of either sublimity or beauty. There has been increasing recognition that the deepest penetration of nature possible to the scientist only makes it more clear that we have in no sense attained finality in understanding any aspect of it. The philosophical scientist is left practically with the poet to refer to the earth as "the shadow of some spirit lovelier still."

It is not possible to express in the compass of a brief general statement the detailed evidence required for discussion of ways in which the influence of science may accentuate or advance appreciation of nature. It is, however, desirable to indicate some of the categories or situations in which science appears to have influence.

The first group would include consideration of a large number of separate or individual items in nature through the more intensive examination of which, by aid of science, we could obtain greater satisfaction. As illustration of this group: Appreciation of beauty in autumn woods may be merely the sensuous imprint of color—as Wordsworth might state it, "borrowed from the eye"—and yet it may give deep pleasure, intensifying with passing of the years. Or, appreciation of beauty in autumn woods may be based on indefinite impressions arising from personal association with such woods in youth or under favorable personal conditions. But to one who knows the complete story involved, this flaming glory at one stage of the biological cycle may also suggest fruition, and bring to mind the whole movement of life through its changes from season to season and age to age, a picture of unmeasured limits and of unfathomed interest.

In a second group, elements of power and movement as expressed in the flow of a river or waves of the ocean can not be overlooked

even by the most casual observer. But evidence presented by bent and folded rocks of a mountain chain shows power and movement just as clearly, although seen at the moment in something which appears completely quiescent. The eye of science adds to nearly every picture of a landscape the elements of movement and power as they have been expressed in activities through the ages. In this group should be classed also our appreciation of great periods of time, through the flow of past ages, and their consequences, as made clear to us in study of nature by scientific methods.

Again the history of thought in almost every organized form, from science to philosophy, has shown development from stages in which the items of the world about us were largely separate, over to a position in which interdependence of practically all the known elements has been recognized. So, as illustrating group three, in science today, the investigator recognizes interdependence of all things in nature, and sees the picture of the present and the past as representing development of a great variety of elements connected with each other directly or indirectly, and so related that no phase of the picture can be considered wholly independent of the others. This *unity of nature* is a matter of great significance in our estimate of values in appreciation of the world about us.

In group four we could place the influence of science as expressed in organic evolution. Many students concerned with the history of human achievement look upon the idea of development, or growth, or evolution as the outstanding contribution of human thought. Coming out of studies by biologists, palaeontologists, geologists, and even of astronomers, we come to see the world today as the product of development through a long series of stages dating back many hundreds of millions of years. Originating in the geological-palaeontological-biological story, the idea of evolution has extended itself to everything from the physical world to social organization. To look upon nature without, on the one hand, recognizing the unity in its diversification or, on the other hand, without seeing the development continuing through past ages to the present and extending into the future, would be to overlook the greatest of all features toward which appreciation might be directed. To say that such appreciation would be merely recognition of scientific fact would be to fail completely in expressing the

mind of the scientist, for to him these great truths bring an emotional reaction at least comparable to that produced by great works of art, whether in painting, architecture, or poetry.

A fifth group concerns appreciation in terms of man's relation to nature. When one looks upon nature, and recognizes its values, there arises inevitably the inquiry: "What does this mean to me? What is man's place in the world of nature?" Without insisting upon details in the story of human origin and evolution, the scientist finds it difficult, if not impossible, to avoid thinking of man as embedded in nature and dependent upon it, and as arising out of it by a process which may be called evolution, or may be described as a mode of creation. Involved in this vision of man's situation there is of course the idea of unity of nature along with the elements of time and movement and evolution.

To one who has the broader view of man's place in nature, and for whom appreciation extends in these many directions, there is a certain satisfaction in recognizing the place of the individual not only in the great world of the moment with all its parts related, but in the succession of worlds in time, with expectation that other ages and other changes may come. Under these conditions there develops in this view of nature a sense of responsibility to the past out of which we have grown, and in which preparation was made for what we now have. There is also recognition of duty by reason of the opportunity presented in life and possible accomplishment of the present. There is also appreciation of opportunity for building into the larger future with its conceivable goals, toward which moves the present world and all that finds place in it.

As concrete illustration of possibilities for advancing appreciation of nature, the Grand Canyon of the Colorado river offers especially interesting examples of progress by aid of scientific study. The Grand Canyon is a magnificent spectacle merely as magnitude, or as color, or as illustration of architectural and pictorial patterns; but perhaps more than in any other way it has human value as a means of indicating what change, movement, and time are, and how they present a background for all human thought and purpose and planning. Without a true appreciation of perspective in depth or height, or of the streaming movement in the currents of change, there seems little possibility of reaching even an approximation to clear vision regarding great events or affairs, whether they concern

nature, mankind alone, or man in the world in which he is placed, or even humanity in the world it is proceeding to make for itself.

The great number of unusual qualities expressed in the Grand Canyon may seem to satiate one's interest in natural features to such extent that enhancement of appreciation by the contribution of science would appear superfluous. And yet there are few places where more numerous or more insistent questions are raised concerning the meaning of the world around us.

While it may appear sufficient merely to accept the canyon as something that stimulates the imagination, the mind immediately reaches out to inquire concerning its origin. Was the earth here pulled apart along the line of that tortuous fissure marking the course of the river? Was the canyon produced by earthquakes or through wear of water? Given adequate time and opportunity for investigation, answer to these questions could probably be obtained by the average mind. Science possesses no magic formulae or methods, but is only the accumulated result of intensive organized inquiry concerning such questions.

One sees the picture of nature here so defined as to include elements of magnitude even more stupendous than those of height and depth which impress themselves upon us so sharply in first visions of the canyon. In addition to height and depth and mass as evident characters, scientific examination makes clear to us elements of vast power involved both in building the walls and in cutting the canyon. Also, we see time represented by stretches that appear almost infinite compared with the limits of experience with which we have acquaintance. Still more intimate examination reveals embedded in this record the story of life through the ages, with its evolution from stage to stage. To the eye of one who views the picture as a whole, this succession of realities inevitably appears as a continuous story, enacted as it were in the presence of the beholder.

The large contribution of science here, both to understanding and to appreciation of nature, makes clear a responsibility on the part of those who represent science for so directing its effort as to bring to humanity not only knowledge but with this adequate appreciation and enjoyment.

It is sometimes said that after examination of the universe about us by scientific methods we have still no clearer appreciation of what

nature is fundamentally than was attained by the earliest students in remote time. It is perhaps true that to both the savage and the savant, nature is still practically inscrutable. It is not surprising that the savage personified natural forces, or that in recognition of these imperfectly understood elements, and of their law-controlled action, some see now a degree of reasonableness in looking upon these features as representing coordinated intelligence or a basic controlling mind.

Modern science does not personify, and has not tended so specifically to attribute what we call intelligence to the elements of the world about us, but it realizes that we are far from fathoming the elements of nature or their meaning.

Furtherance of knowledge, while tending to define limits in human powers, has also increased respect for man as a being, and for the possibilities of his creative activity. And yet, increasing knowledge shows the universe around us to be so stupendous and so complex compared with man that we see nature as something wider and deeper, and in every respect more wonderful, than has heretofore been assumed. Perhaps the recognition by science of a greatness in nature that does not lend itself to description in available terminology is evidence of a degree of appreciation beyond that expressed in terms of anthropomorphic conceptions based upon our own limited experience.

In Concluding

Influences exerted by scientific agencies represented here through the Natural History Survey, Geological Survey, State Cabinet of Natural History, New York State Museum of Natural History, The University of the State of New York and State Education Department have affected the human interests and activities of this country in more ways than we can catalogue adequately. However large the values may bulk in influence concerning what appear to be dominating factors in life, such as maintenance of existence and opportunity for progress, there is reason to feel that advances in understanding and in appreciation of the natural world do not rank second in importance to other contributions.

What has been done here by these institutions in adding to knowledge in several divisions of natural history is an outstanding contribution, not only for this country but for world science. In a

quite unusual way the facts and their interpretation have been related to formulation of what we call natural laws and to advancing understanding and appreciation of our natural environment.

There have been few investigators in American natural science who have attained as high a rank of scholarship as interpreters of the earth sciences as John M. Clarke, Director of the Museum from 1904 to 1925. Also Charles C. Adams, the present Director, who followed Clarke in 1926, has exerted wide influence through forwarding the understanding of nature both primitive and domesticated, and by so linking purely factual science to art and to human interest as to better appreciation of nature and increase our joy of living.

More careful analysis than I am able to give will show that in activities of this past century the peculiar conditions of location, support, and splendid constructive policy of the institutions here have all contributed toward exceptional accomplishment in advancement of culture and its living uses.

RESEARCH AND PUBLICATION

STATE AGENCIES OF UNIVERSITY PUBLICATION

Two Types of Institutions

Problems concerning publication in state universities resemble those in institutions not supported by state appropriation, in so far as their relation to fundamental organization of graduate and research work is concerned. Differences develop through origin of activities bringing about a peculiarly close relation between state institutions and the communities by which they are supported. In many cases these activities vary widely from those generally recognized as pertaining to universities. The present moment finds us with one class of institutions, the state universities, in which the work may be directed to a large extent toward assistance in every-day business of the state, while other universities, feeling less immediately the fluctuation of community needs, may give themselves more largely to examination of the critical or fundamental principles of knowledge. The differences now apparent may not be fundamentally necessary. The tendency is possibly toward similarity rather than toward divergence of university types.

Relation of Publication to Graduate Work

Influence on the Faculty.—As in other institutions, publications that emanate from the faculty of a state university invariably have a large influence on the development of graduate and research work, and upon the vitality of the teaching force. We may assume that the graduate school exists mainly for the benefit of the student wishing to attain professional standing in the subject to which he has devoted himself. If this is true, the ideal organization of the school, from the point of view of the student, is one leading him through an apprenticeship with master-workers, and bringing him finally to a point at which he is able to show through results of his

Paper prepared on behalf of the University of California by John C. Merriam and presented at the meeting of the Association of American Universities at Princeton University, November 6, 1914, by Armin O. Leuschner. *Proceedings of the Association of American Universities, Sixteenth Annual Conference, 1914*, pp. 50–59; republished in modified form in, and reprinted here from, *School and Society*, vol. 1, no. 25, pp. 871–879, June 19, 1915.

own work that he is worthy of rank as a professional. Any method of conducting graduate work which does not involve apprenticeship leading to a stage in which the student acquires some measure of independence is open to the criticism that the graduate going out to work alone, is, to a large extent, an unknown factor so far as his judgment of new materials is concerned.

The possibility of apprenticeship leading to independence implies continuous practical work in the field covered by the staff of the graduate school, and implies further the necessity for some method of caring for the output of the staff. If there is no output, we are not dealing with real work, but rather with play examples. Failure to secure adequate expression of results means that the investigator does not obtain full value for his attainment. The stimulus for work is diminished, and the staff of the institution fails to reach the desired stage of efficiency in leading graduate study.

Considered in the broadest sense, publication may mean realization of the results of any kind of work in permanently available form. If the work is engineering, it may be the building of a bridge. In philosophy it may be a long and intricate discussion of materials situated near the edge of the widest field of knowledge, and not as yet susceptible of simple expression.

The means of publication of results of research are exceedingly numerous. Journals of all kinds, and book firms waiting to receive materials which the public desires, are ready to take over any real contributions to knowledge. It is to be presumed that the larger part of the output of investigation in any university will naturally go through the numerous channels provided to care for work in special subjects. Excepting journals established for purely commercial purposes, a large percentage of the available publications into which the majority of university papers go have been established for definite purposes which do not comprise caring for the work of universities. The material turned out by universities may indeed place upon them an unwarranted and unexpected burden, even though in some instances a share of the financial support is contributed by members of the faculty as individuals, through membership fees in scientific and technical societies. There is no financial return to the authors, though there may be compensation in scholarly advancement. The university, to which this work is absolutely necessary, does not share in the support, unless it be

through increase of salaries to individuals making themselves useful through publication in this manner. The question naturally arises whether the institution requiring research and the realization of its results as a part of its program is not fully justified in providing means for the support of some portion of the output. The university then contributes a part of the cost, and publication becomes easier and is generally more efficient.

Direct Influence of Publication upon Graduate Students.—The influence of home-controlled publications of a state university upon students of the graduate school is larger than is commonly recognized. Constructive work done by mature students with the idea of publication in mind gives a much higher value to the judgment than in cases in which the final disposition of results is uncertain. Presentation of the work of students in the same series with that of members of the faculty lends dignity to graduate work provided the student publications are judged by the editorial board on the same basis of worth that is used in judging work of the faculty. A danger exists in the possibility of accepting papers of relatively little value, and thus reducing the standard of the university publications. This can be prevented by reducing student papers to the minimum of space in which the contribution can be presented. In general the tendency has been to allow the student to use the maximum range of statement in order to indicate his understanding of the subject in all of its aspects. Elaborate papers are valuable to the student and to the members of the faculty judging their work, but not to the world of scholars.

Theses for higher degrees may be issued through university publications on the same basis as other scientific work. The university should encourage the publication of theses in series maintaining high standards. Independent publication financed by the student is dangerous, as it eliminates the check of established standards. Publication of doctors' theses is required by most universities as an indication of the desire of the institution to make certain that the dissertations are completed in the most satisfactory way and made available in the most useful form.

The graduate student at an institution continually producing scientific work through publication, in nearly all cases will pass through the experience of writing and publishing before the last year of his work for the doctorate, and for this reason his thesis will

be written with much more care and understanding than are dissertations which represent the first expression of untrained authors.

Relation of Publication to Library.—The relation of university publications to the library is necessarily close. Research requires increase of current literature. By utilization of the publications which the university press makes available the library may increase its collection of serials through exchange. A well-regulated press should be able to produce its publications at a cost much less than the sale price of serials of scientific organizations. The increase of accessions in the library by exchange presumably will be largest in the direction of the principal lines of research expressed in the publications of the university, and thus will assist materially in increasing facilities for work in the fields of investigation for which the institution may be best fitted.

The Peculiar Problems of Publication in the State University

Contrary to expectation, it has come about that the value of state universities as centers of research, in furnishing expert opinions, and in making entirely new information available, has come to be recognized by the people of the states as ranking in importance close to the peculiar function of instruction for which the universities were presumably founded. Following this recognition of the situation, the states have commonly demanded more and more the increase in efficiency of these particular phases of university work.

A state university probably feels more definitely than other institutions its duty toward the community in pushing forward the boundaries of knowledge and in furnishing the raw material which will make future progress in science and the arts possible. Progress of the present generation is largely dependent upon the imperfectly understood advances of science in the preceding age. Fifty years ago a large part of what is now included in the field of concentrated commercial exploitation found difficulty in obtaining recognition outside the technical discussions of scholars, or in publications other than those for purely scholarly work. The cessation of purely scholarly work for half a century preceding the present day would have robbed us of a valuable heritage. This work must proceed if the next generation is to keep the pace.

In addition to the requirements of the university as a center of research and as a bureau of information in matters ranging from practical affairs to scholarship, there has come the demand that the state university, as the culmination of the educational system of the state, shall make available to the community the means of general dissemination of information through university extension courses.

The new demands on state institutions have placed upon them an added burden of publication, which appears largest in the departments of agriculture and university extension.

Organization and Administration of State University Publications

Organization of the publications of state universities is exceedingly varied, and in most cases is an expression of history rather than of plan. In many instances the organization could be much improved if it were recast, but convenience of handling, and disinclination to disturb bibliographic sequence continue the original forms.

At the University of California, the official publications may be grouped as the Scientific Publications, including results of original research in scientific, literary and philosophic subjects; Publications of the Department of Agriculture; University Syllabus Series; Library Bulletins; University Extension Publications; Administrative Bulletins, and the *University of California Chronicle*. Concerning the publications of this university, the writer may, perhaps, be pardoned for giving a relatively full account.

Publications of the Lick Observatory, containing the results of valuable and extensive research at the observatory, have been in existence since 1887. They are issued under the direction of the Lick Observatory, but pass through the hands of the editorial committee. They have up to the present time been financed either by appropriations of the legislature or by grants from the regular university funds.

In 1893 the Bulletin of the Department of Geology was established to include the results of research carried on in the department. Following this precedent, the scientific publications have been extended to include at the present time twenty-three series, embracing geology, botany, zoology, physiology, pathology, psy-

chology, philosophy, philology, economics, education, history, mathematics, engineering, agricultural research, and other subjects.

The purpose of these so-called scientific series of publications is the putting down in the most useful form of results of original research carried on by the university community. It is not expected that the members of the faculty or of the university will in any sense limit themselves in their publication to the university series. They are rather encouraged to make use of other regularly established channels in the distribution of scientific information through journals and other media of publication. The university publications do, however, offer a most satisfactory means of bringing together the results of original research at this institution.

It will be noted that the scientific publication series include certain phases of work in agriculture and engineering. The papers accepted in these series are largely scholarly work resulting from research bordering on pure science.

The scientific publications of the University of California, the syllabus series, and a portion of the administrative bulletins are administered by a committee, consisting at the present time of nine members appointed from the faculty by the president of the university. This committee is an administrative body to which the president and the regents delegate the direction of this phase of university activity. The committee formulates the policy of the University Press, appoints editors and boards of editors, receives publications from the editors, and carries the work of publication up to the point of distribution of the product. Up to 1914 all publications going out from the university, excepting the authors' reprints, were distributed by the University Press. Very recently an arrangement has been made by which the press turns over to the library such publications as are needed for exchange, and the handling of exchanges is carried on by the library.

The executive officer of the publication department is the manager of the University Press, an administrative officer appointed by the regents. He is not a member of the faculty, but is secretary of the editorial committee.

The editorial committee reports to the president and regents concerning financial and administrative affairs of the department, and, as a committee of the academic senate, it reports to the senate on matters relating to the academic significance of the publications.

The scientific publications are supported by a special budget for publication set aside from general university funds.

The publications of the department of agriculture are under the direction of the college of agriculture and are issued under the titles of Bulletins of the Agricultural Experiment Station, and Circulars of the Agricultural Experiment Station. They include a wide range of subjects, covering any information of practical value in agricultural work. The publications may represent the results of scientific investigation, or they may present a compilation of general information for the benefit of the agriculturalist. These publications are issued free of charge, in large editions, and are widely distributed through the state for the benefit of all persons interested in this work. There have been issued 246 bulletins and 121 circulars. The mailing list now contains about 18,000 names. In the present year the volume of publications of the department of agriculture of the University of California is nearly as large as that of all scientific, literary and philosophic publications combined, with the exception of the Lick Observatory Publications. In the past year the total number of copies of agricultural bulletins and circulars issued approximated 410,000. The value of these publications to the state is very large, as is evidenced by the interest of the agricultural communities in this work, and by their demand for more information issued in this form. Publications of the department of agriculture, excepting those issued in the scientific series, are supported from the budget of the college of agriculture.

The University of California Syllabus Series includes at the present time over 50 pamphlets ranging from brief outlines to incipient text-books on a wide variety of subjects covered by regular university courses. The syllabus originated as a topical outline with references, but has gradually expanded until it bids fair in the near future to become a text-book in the true sense of the term. The publication of the syllabus series is financed at present through the fund set aside for the scientific and literary series, but the returns from sales are paid back to this fund. The cost and the size of the edition in the case of each syllabus are determined by the editorial committee, and such an arrangement is made as will under ordinary conditions make the syllabus pay for itself within a period of two years. The series contributes much to the efficiency of instruction.

The library bulletins contain bibliographical material and periodical lists issued by the library. They are financed by library funds and are passed through the hands of the editorial committee.

The university extension publications are financed by the university extension division, but the publications pass through the hands of the editorial committee. The publication of this series is just beginning, but may be expected to expand very greatly in the near future, and to meet a large need throughout the state.

The *University of California Chronicle* is an official record of addresses delivered at the university and of events of general interest. It is financed through funds distinct from those set aside for the scientific and literary publications and is administered by the editorial committee.

The administrative bulletins are financed by the administration of the university and are edited in part by the editorial committee through the recorder of the university, who is the editor of this series.

The University of California maintains its own printing plant, at which all publications are now handled. In exceptional cases of congestion in the home office, or in case of unusually difficult matter for which proper facilities in its own plant are not available, papers may be printed elsewhere.

During the early history of the University of California Publications, a considerable volume of material was issued through the office of the state printer at Sacramento. These publications included the results of work at the Lick Observatory and astronomical papers produced by the department of astronomy in Berkeley, a large volume of agricultural publication, administrative bulletins, and a limited amount of material from various departments. The cost of these publications was defrayed by special legislative appropriation.

In recent years the tendency has been to concentrate all publication at the university press in Berkeley. Ease of access to the university printing office situated on the campus, and convenience of cooperation between the editorial board and the university printer, have made it seem the part of efficiency to do as much work as possible on the campus. The result has been a great enlargement of the volume of printing, with consequent need for larger and better equipment. At the last meeting of the legisla-

ture, no appropriation for printing university publications was made apart from the general budgets for support of the university as a whole.

At a number of other state universities, as the University of Wisconsin, University of Minnesota, University of Illinois, and others, a considerable volume of publication is issued each year. A great variety of methods is used in the organization and administration of this work.

The University of Wisconsin publishes the bulletins of the University of Wisconsin, the publications of the Washburn Observatory and the publications of the department of agriculture. The bulletins are published in six series, embracing economics, political science, history, philology and literature, science, engineering, and university extension. They include the results of research work, and are supervised by a committee of the faculty of which the university librarian is chairman. The publications of the Washburn Observatory are issued under the editorship of the director of the observatory. The publications of the department of agriculture consist of Publications of the Agricultural Experiment Station and Bulletin of Wisconsin Farmers' Institutes. They are under the charge of the college of agriculture. The bulletins of the university and of the astronomical observatory are charged against the general university fund income. The agricultural publications are supported by specific appropriations for publication.

The University of Minnesota issues research publications in five series, called Studies in Social Sciences; in Philosophy, Psychology and Education; in Language and Literature; in Physical Sciences and Mathematics; and in Biological Sciences. The university publishes also Minnesota Botanical Studies, Minnesota Plant Studies, the *School of Mines Experiment Station Bulletin*, Current Problems Series, and Contributions from the Department of Anatomy.

The purpose of these series is publication of research papers which otherwise might not be printed, and the dissemination throughout the state of studies having a definite relation to the life of the state.

The research series and current problems series are administered by the publication committee of the graduate school. The other publications are issued by the departments which they represent.

The printing of all publications is in the hands of the senate committee on printing. The distribution is under the control of the librarian. The publications are financed by grants from the research fund of the graduate school, and from the general funds of the university.

At the University of Colorado, two publications, the *University of Colorado Studies* and the *University of Colorado Bulletin*, are issued. The policy of the editors is to bring out in the *Studies* original articles by members of the faculty. The editor-in-chief is appointed by the president. There is no publication committee and no manager. Publication is financed out of the general university funds. The primary distinction between the *Studies* and the *Bulletin* is that the latter contains articles of a more popular nature.

At the University of Washington a committee of the faculty, known as the publication board, has charge of all university publications. The university issues the *University of Washington Bulletin*, Occasional Papers, and *University Studies*. Thus far, the publications have been financed entirely from departmental funds, but for the coming year it has been recommended that a separate item of the university budget be established to care for publication. The university is just entering upon a plan for the supervision of all of its publications. The *University Bulletin* will be reserved for administrative papers. The university extension publications will form a distinct series. The Occasional Papers and *University Studies* will be discontinued. The University of Washington publications will include the serious scholarly work grouped in distinct subseries, as University of Washington Publications in Natural Sciences, in Philology, etc. An editor or an editorial committee will be elected for each series by the members of the faculty in the field represented by the series.

The University of Michigan supports a series of publications called the University Studies, comprising monographs in three groups: The Humanistic Series; the Historical Series; and the Scientific Series. In addition to these, the university supports a number of other publications which are mainly collections of papers and articles bearing upon the scholarly work of various departments, as the Humanistic Papers, Publications of the Astronomical Observatory, Occasional Papers of the Museum of Zoology, and

Contributions from the Physical Laboratory. The executive board of the graduate department administers the publications. There is no general editorial committee, but special committees may be appointed for the editing of individual papers. The publications are financed mainly by contributions from friends of the university. The board of regents, however, has frequently granted small appropriations. Only in exceptional cases is the author obliged to contribute part of the expenses, and he is then reimbursed from the income realized by the sale of the publications.

The University of Kansas publishes the Science Bulletins which were preceded by the *University Quarterly*. Bulletins and the reports of the geological survey have also been issued by the university.

The University of Missouri publishes University of Missouri Bulletins; Publications of the Agricultural Experiment Station; and the University of Missouri Studies, in five series known as Literary and Linguistic Series, Philosophy and Education Series, Mathematical Series, Science Series, and Social Science Series.

The University of Nevada publishes a bulletin series, containing executive papers, university addresses and articles on subjects of immediate interest, and a series of studies containing results of scientific investigations. The publications are administered by a committee on publication, appointed by the president. This committee exercises its functions subject to the advice and consent of the president. A single sixteen-page monthly, *Better Farming*, is issued under the management of the college of agriculture. All of the publications are financed from the general state appropriation to the university.

Conclusions

The examples given above will suffice to indicate the general types of organization and administration prevalent among the state universities. There is generally a tendency to separate the scientific, literary and philosophic publications, representing a large part of the scholarly work of the university, from other subjects, and to place them in the hands of an editorial committee composed of members of the faculty. In some institutions special series are under the management of the departments in which they originate. Agriculture, engineering, mining and other applied

sciences with problems of a nature different from those presented in the scientific series are commonly separated and under control of the colleges or departments in which the work is done. University extension is generally under distinct control.

In nearly all institutions further concentration and more uniformity would be advantageous. Where the volume of publication is sufficiently large, a university editor or manager of the press should be able to assist in standardizing forms, and in caring for matters of detail which would otherwise cost much time and interest that the faculty committee might spend to better advantage in other work.

Uniformity in style and in standards of presentation of materials in different series should not be pushed too far. Editors and authors who have slaved for months or years in describing scientific results of importance are inclined to feel that they have the clearest view of their own work. The interest and enthusiasm of the author for his work are worth more to the university than is strict adherence to details of form.

The increase of publication at state institutions in recent years seems to show that the results of university research meet with favor from the people of the states. We have entered a stage in which the support of investigation and publication of its results are to be cared for by the state to a greater extent than in any previous period. Generous contribution by individuals and by many organizations will continue, and with these the increased and regularly contributed support from the community will make for rapid advance, and for greater efficiency in the future.

University of California

THE CONTRIBUTIONS OF RESEARCH

I SUPPOSE that a man of the academic type is presumed to interpret "research" as limited to that aspect of constructive work which goes on in the university laboratories. Though we may think of research as academic, it represents also whatever effort is put forth to build, to construct, or to make whatever is developed of new ideas or of materials. One might perhaps think of research as represented more largely in the laboratories of industrial institutions than in those of educational institutions. The largest research laboratory I know is that of a corporation in which the scientific output is comparable in many ways to that of several universities.

Research must, for proper discussion, be divided, as Dr. Durand suggested, into that which is applied and that which is sometimes spoken of as "pure" science, which, I think of rather as disinterested investigation. One must keep in mind these two interlocked phases of work, both of which are important, neither of which can stand without the other.

Applied research is that which one sees in the industrial laboratory, in which there is a specific problem for which solution is desired. That problem may be a question of illumination—it may relate to the filament in the lamp, or it may relate to the glass which surrounds it, or it may relate to the way in which it is designed or wired, or to the nature of the current; but it is a specific problem which is set before the investigator, requiring a specific answer. In settling problems of this sort one naturally draws upon all materials available; but we often discover that the shortest path or what seems like the shortest one to the desired end is one of the roads that cannot be travelled, and while one sees the goal it is not possible to reach it. Another investigator, who makes wider excursions but always with his eyes open, arrives at this goal. This illustrates the difference between specific applications of research and research of the disinterested investigator.

In report of the Committee on Scientific Research, Commonwealth Club of California, September 25, 1919. "War Time Advances in Science," *Transactions of the Commonwealth Club of California*, vol. 14, no. 9, pp. 405–411, October 1919.

The disinterested investigator may seem to roam about aimlessly but with his eyes open, with the idea of arranging, classifying, and using all the facts that he may obtain. I once thought that the academic man was the only one concerned with these researches, but have found that men in the industrial laboratories are among those who insist most strongly upon them. I have also discovered that some of the strongest supporters of disinterested research are engineers who direct the great industrial laboratories. They say that in their institutions they are raising questions concerning fundamental theory which need answer, and that they realize that there are whole fields of investigation important to them of which as yet we know but little. Many of these problems must be worked through by men concerned with fundamental research in universities or in research foundations.

One of the greatest lessons that comes to us from a study of research in the war is found in the fact that the results of investigation used were largely those which had been completed and laid away, card catalogued and labeled before the war began. I was one of those enthusiasts who thought that research could make great contributions during the war. I preached that the stimulus of the war ought to produce certain ideas which might not be produced under peace conditions. As some of my friends considered it possible for the war to last five or ten years, it seemed that certain of the researches initiated within war time might finally be determining factors in winning the war. If the conflict had lasted six or eight years, it might have been won by results of investigations initiated especially in the interests of the nations' war-times need.

As the science applied was that which we had before the war, it seems that we must agree with the view that necessity is not the mother of invention. Necessity does not generally create; it applies. If you have no ideas before the need comes you will create little. The man who invented the steam engine was not particularly in need of such an engine at the time he invented it; but he discovered a principle which later on gave us the engine and all of the many inventions that came out of that particular application.

The new scientific ideas then that were applied during the war were not only in large measure those which we had ready, but they were also in a large number of cases those things which had been

worked upon by disinterested investigators, and had seemed to be nothing more than the toys of students. The lesson that I want to bring out is that in the future we must keep a group of men engaged continuously in the investigation of every field of research, and that these investigators must keep their researches some distance in advance of the needs of the moment. It is an exceedingly dangerous thing to be at the end of the stock of materials you wish to use, whatever the business in which you are engaged. You do not know what the next need will require, but you do know when that time comes you will wish to have the ideas needed without having to devise them.

During the period of the war productive research in this country dropped to a relatively low level, and at the present moment, at the end of the war, we have come nearer to using up our stock of research contributions than during many decades past. This means much to us because at the present moment we have use for more kinds of new ideas than in any stage for many years. Reconstruction presents especially large needs by reason of the fact that it covers more activities than war. What we applied in war bore only upon one particular project. Now we are engaged in a great variety of kinds of construction, and find many problems that urgently need solution. One of the greatest requirements we have today is the placing of as large a number of men as can be secured upon investigation of questions the solution of which we cannot attain without intensive study.

I am expected to say something this evening regarding the applications of science in promoting efficiency and in adding to the productivity of the country during the war. I may begin with illustration from those applications tending to increase the efficiency of the nation. Efficiency, as I see it, is the using of what we have with the least waste to secure the largest result. There is no place where we have the idea of efficiency put into effect more clearly than in use of the energies of human beings. I do not believe that we can find a better illustration of the use of science than we secure in this kind of application in psychology. A psychologist is a man who gives himself to a study of human action; he does not know whether he will be called a philosopher or biologist. He stands at that point where we tie mind to matter or thought to the brain.

I remember very well a meeting at the University at the beginning

of the war in which some of us considered the contributions which the faculty could make. Among other departments we discussed what the psychologists could do to help win the war. We were sure that an important contribution could be made, but it seemed a path-finding undertaking. As I view it now, there is no group which came nearer to the first rank in contributing to efficiency in the war than the psychologists. Some of the things they did you all know. Everyone is acquainted with the tests of the psychologist for determining whether men brought in as recruits would make good aviators. We know that some of the tests gave little result. It was not always possible to say that a man would make a good aviator, but it was possible to ascertain that some men could not make aviators. In that way we saved lives, saved the time of the officers in training, and saved the use of machines. If the psychologist had been given time he would no doubt have told us which men would be good marksmen and which men would have courage, but that stage was not reached.

Another field in which psychologists did most important service was in the working out of the plan for rating officers and men; in other words, for development of an efficient method for promoting men, making possible the rapid development and organization of an army. This was of much importance with the great number of men to be handled. The plan had faults of course. You cannot have anything constructed in such a short time that will not meet difficulties. But it seemed to work. It will be improved in time, but it added greatly to the efficiency of the force that went across the sea. So important was this contribution that Dr. Scott, a leader in the work, was called away from his position shortly after the end of the war to assist in development of plans for efficient organization of personnel in peace-time work of various types. This work has been organized in the Scott Company which is continuing an important contribution to business operation in America.

Out of the psychologists came another group that made an important beginning before the end of the war; this was the section which had as its function consideration of the morale of the men in the army. This was the business of scientifically estimating the value of certain qualities of mind, and which had as its object the working out of plans by which men could be kept at all times in the best mental condition to give them the stamina, courage, and the

strength. This was a scientific organization. It was a part of the army, and came to be an important phase of its work, contributing to the efficiency of the nation at war.

I must not weary you with applications of this nature and will shift to one or two points in another field of science. I hesitate to approach the field of astronomy and mathematics, in which Dr. Durand and Dr. Campbell know so much more that is worth discussion. When in Washington one of the group of specialists that impressed me most was a combination of astronomers and mathematicians concerned with mysterious formulae which only a few mathematicians and astronomers know. These men took up the problem of flight of projectiles in artillery practice. They found that a slight modification of the form of the projectile might help greatly with the range. Then they investigated the gun. A part of this study was mentioned by Dr. Durand in consideration of the atmospheric conditions which control artillery calculations. In study of the flight of the projectile they used mathematical and astronomical methods that had not been applied previously. They greatly bettered the pattern of the gun, and they increased the range. This is another contribution of pure science to the effectiveness of the army. The mathematicians and astronomers had been working similar problems in advancing their special lines of study in time of peace.

The contribution of specialists in mathematical research to strengthening of artillery suggests that we must always assume that there will be progress in any field of investigation in which there is competition. We must continually look ahead for application of the last possible item of information from whatever source it may be derived. We saw many old ideas set aside when we came into this war. I hope if we conceive of another war as possible we will keep continuously prepared in the future by contact with those groups of investigators who have closest acquaintance with research in fields through which new advances will presumably be made.

I shall not give further illustration from physics and astronomy, but I cannot avoid mentioning one that represents this contribution to efficiency by the way of biology. This morning when I opened "Science," the official organ of the American Association for the Advancement of Science, I noticed a very interesting article which was in effect a letter from the Surgeon-General of the United States

Army to the Rockefeller Institute for Medical Research, expressing the thanks of the Medical Department for having had the great facilities of the institute placed at its disposal for research, teaching, and care of the sick, during the war. There was no group of men that gave us a larger contribution than those who represented biology and medicine. They kept the army in health and strength. They returned the wounded, and they almost brought back the dead. In medicine there is a focusing of chemistry, physics, and various branches of biology upon the study of human life. From the Rockefeller Institution and from other institutions we have one of the most wonderful examples of increasing the efficiency of the army and navy that we know in history.

I am also expected to say something regarding relation of research to the productivity of the country, and this I must reduce to narrow limits. There is much to be said about food; there is much to be said about all kinds of products in which scientific investigation had an important place. To indicate that research had some part in matters that concern food, I might only say that the United States Department of Agriculture has available for research in the next year something like twenty millions of dollars. This indicates that the country considers that research has been an important instrument in helping us to produce through this field.

A special example which I wish to give of the part which science played in definite production in the war is this: Chemistry, without any question, was one very large factor saving us from defeat. It makes no difference how many soldiers we might have had, or how much food, had it not been for the chemists who came to the front and met the tremendous menace of poison gas, the allies would have known defeat. Chemistry in this instance made a clear contribution of an immensely important production, which came partly out of the science of the research laboratory, and partly out of the science of the industrial laboratories.

I will close with just this word, which is to repeat what I said to the effect that the science which was used in this war period was the science which was available before the war. I make this remark now because it seems to me we must bear in mind that we should at all times have a similar stock of constructive material ready for whatever emergency may come. Good San Franciscans never expected the particular kind of a fire that came some years

ago and shook our homes before it burned them; we have not looked forward to any such calamity as came to us. Good citizens did not look forward to such a world conflagration as came out of the confusion of nations in Europe; and we may not now sit back and assume that for all time in the future we are to be spared great cataclysms and great catastrophes. We do not know how the next one will originate. It may come through some source that is not now clear to us. We should be prepared for the new emergency by reaching out to know at least in part new regions of thought and by fitting such knowledge into our present store of organized information. In other words, I am making a strong appeal for that kind of intelligent disciplined research which will constantly keep us beyond the forefront of industry and of applied science, and make us ready to meet new conditions whether they be emergency incident to catastrophe or the needs of industry and art reached through the ever increasing complexity of our civilization.

THE FUNCTION OF EDUCATIONAL INSTITUTIONS IN DEVELOPMENT OF RESEARCH

In this day of application of science in every department of human interest, we naturally find investigative work conducted by a great variety of institutions. The relating of research to this wide range of activities is now recognized as essential. It is also considered important that in all types of constructive work there be a certain similarity in method of approach, but recent studies have raised a question concerning possible duplication of effort, and therefore of inefficiency in our organization of science and research.

The following note has been written with the aim to define the special functions characterizing research of educational institutions in contrast with those of other organized effort directed toward the advance of knowledge. For the purposes of this discussion it has been necessary to consider a tentative classification of fundamental types of research agencies. Fuller recognition of the specific objects in these several fields of endeavor, it is believed, may lead to larger efficiency and better scientific organization of the country as a whole.

Without assuming to present a complete or exact classification, we may divide our greater research efforts into five groups: (1) research of practical application in engineering laboratories; (2) governmental bureaus and laboratories; (3) research foundations; (4) museums and allied institutions; (5) educational institutions. To these five a complete statement would add several of lesser magnitude, among which a very potent force is found in effort of individuals working privately, as has been done to the great advantage of science by many pioneers in investigation. In order to make clear the position of educational institutions with relation to the other four kinds of research agencies, it is necessary to give an approximate definition of each type.

(1) The expression of research referred to as "practical applica-

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tion in engineering laboratories" includes use of science in development of economic interests in the great variety of ways in which investigation contributes to the good of mankind. The words "engineer" and "science" are here used in the widest sense, covering the appliers of knowledge secured by investigation. The operations of this group might be illustrated by the constructor of railways, the builder of aeroplanes, or the dentist. The work of the engineer in all of the fields in which he operates may unfortunately be carried on by rule of thumb application without consideration of the special merits of each case. The true engineer we all recognize as one who views each problem as a new subject for special study. In a large measure his judgment must be based upon previous experience with similar studies, but his greatest success comes through realization of the fact that each bridge to be built, whether it be intended to cross a river or only to reach from one tooth to another, presents a special problem not identical with any previously considered case; and that failure to see the individual peculiarities may mean inability to make full use of the principles which are his instruments. The successful engineer is continuously engaged in the application of research methods.

In a still larger sense does the engineer concern himself with research problems by consideration of questions which are not merely specific applications, but involve principles which must be better understood before he is able to proceed. The dentist recognizes that knowledge of microscopic structure of the tooth is of fundamental importance in his treatment of tissues if this work is to have value in a degree of permanence measured in years or tens of years. The railroad builder realizes that not all rock foundations give real stability to a railway bed, and that an understanding of the material through which he cuts may determine the ultimate value of his constructive work. These investigations in engineering inquiry we often designate as research in applied science. They differ from those in so-called pure science only in the fact that the research of the engineer is specifically directed, and by nature of the inquiry is rather narrowly limited; whereas the real solution of the problem may lie in a rather remote field. The railway builder may find the answer to his engineering questions in special phases of chemistry or petrography which were not included in the curriculum of his training course.

Even with the limitations which are set in investigations designed to meet specific needs in restricted fields of applied science, we must recognize that the everyday operations of great laboratories conducted by far-seeing corporations are developing some of the most significant advances in fundamental science of today. The student of pure science must always keep in close contact with these special researches, both to be helpful and to receive from the engineer the great wealth of data which should be incorporated into the organized body of fundamental science.

(2) Government institutions, as exemplified by the federal bureaus and laboratories of the United States, represent a field which is in some respects intermediate between that of engineers who apply and that of the special students of pure science concerned only with the principles of their subject. The laboratories of government departments exist for the special purpose of contributing for the benefit of the community. It is necessary that they serve as sources of information for practical applications and for interpretation of the principles of science to the great group of enquiring engineers throughout the country.

Consideration of scientific problems relating to specific community needs leads the government bureau to undertake far-reaching and fundamental investigations in the broadest fields of applied science. Such researches, by reason of the wide range of interests covered, may extend farther than the studies of the engineer or the corporation. As institutions which stand for a continuing people, the government bureaus should be able to undertake inquiries from which results might first become available to later generations. It is unfortunate that budget requirements and responsibilities of political parties tend to limit us in handling of projects which should be continued for long periods or with large funds, for the expenditure of which immediate returns may not be visible. It is presumably true that all science has its application in one form or another, but exceptional vision is required in organization of government work to make it clear that every phase of each investigation undertaken represents efficient application of science for real needs. By reason of its practical limitations the government organization may lose opportunity for consideration of certain critical problems, the settlement of which would ultimately be of great advantage to the state.

(3) Research foundations, with ample resources, freedom of choice in selection of objectives, and with trained men of vision directing their researches, have given opportunity not otherwise available for exhaustive investigation of fundamental problems and groups of problems without regard to the time required in the study, and without reference to immediacy of pressure for application. These institutions have in some measure covered the fields for basic investigation which the corporation engineer and the government bureau could not readily reach. The efficiency attained by these foundations, the vision with which their problems have been selected, and the great contributions which they have made to science, to human thought, and to application of science in everyday life, rank among the greatest achievements of American science.

(4) The great museums of America have been strongholds of research in the natural sciences. Their function has generally involved the special study of wide or narrow geographic regions to which they are related through circumstances governing their origin. The museums have also served a most important purpose as educators in natural history, supplementing in a vital way the work of the schools and universities. Through interpretation of science to the great public the museums have greatly assisted in the effort to make knowledge and reason the basis of our community judgment, and to give research the fullest opportunity to serve the people.

In organization of purely research projects the museums have contributed a large share of the material upon which the advance of American natural history has been based.

The work of these institutions is in general characterized by their peculiarly close relation to the public welfare, both in effective educational work and in the support of fundamental investigations for the sake of their human interest. They fill a most important place in the scheme of our research development.

(5) The educational institutions of America, as represented by the universities and colleges, have always had a large place in the advance of knowledge in all its phases and in its application. Their range of operation in constructive scholarship has been as wide as the limits of learning and its use.

In schools of engineering and agriculture, research has been

largely on specific problems of application not differing from those of the engineer's laboratory or the government bureau. Here, as in the departments of fundamental science, the researches have also ranged into all phases of description, organization, interpretation, and analysis in special phases of science for which no immediate application is considered. These activities have been financed in some part by the universities, and in part from the pockets of the professors. Considerable support has also come from business interests, from government institutions, and from research foundations.

The university or college includes constructive work as a necessary part of its regular programme for at least four reasons, which may be stated as follows:

(*a*) Investigation is an indispensable means of keeping the faculty in a position to present the most fundamental and most advanced knowledge through its teaching.

(*b*) Training in creative or constructive work is one of the most important phases of teaching and can be carried out successfully only through actual experience of the student.

(*c*) The state will naturally depend upon the institution of higher learning as an exceptionally organized group of constructive experts prepared to consider urgent questions requiring investigation.

(*d*) As a body representing a wide range of closely interlocking subjects having continuous relation to research in one form or another, the university affords unusual opportunity for correlation of knowledge on questions in new fields of thought.

In considering the first reason (*a*) we must realize that, even if the universities be assumed to exist only for teaching, they are expected to present the most advanced thought, and we cannot keep them in a position of leadership in understanding and in training without a faculty continuously setting forth the best in thought and experience in every subject. This condition can be maintained either by continuous research on the part of the faculty or by continuous renewing of the membership of the faculty. Continuous replacement of individuals is impossible, as the institution is a great and complex instrument in which the parts can be kept in proper adjustment only through long contact. It therefore becomes necessary for the faculty to keep its position by continuous growth of its members. If this process is merely imitative, the

teacher is not an authority. The only way in which he can be assured of growth is by working in his specialty. This constructive operation involves intimate knowledge of the fundamentals of his subject and definition of the limits and relationships of his chosen field of study.

More than this, the function of teaching in an educational institution does not concern alone the retailing of facts already assembled: it must include that kind of understanding of the subject which will prepare the student for his task as a leader in the future. To become such a leader the student must look beyond our present knowledge and experience with the expectation of accomplishing things which have never before been done. No good instructor can avoid recognizing this need of his students. No teacher who sees this requirement can fail to make a serious effort to determine the direction of advance in constructive use of his subject, if for nothing more than to point out to students the trend of the path and the preparation necessary for those by whom it will be extended to new fields of usefulness. It is hardly possible for the instructor to obtain a clear view of future development in his subject without intimate personal relation to the most advanced work in progress.

From the point of view of the student, training in constructive work or in development of creative imagination, suggested in point (*b*), must be considered of importance at least equal to the securing of information or the disciplining of the mind to habits of work. As in no other type of mental attitude, this involves the acquiring of a distinct love of the work and understanding of its purpose. It is not conceivable that the university will neglect this extraordinarily important aspect of the student's preparation for future activity or that it will expect him to proceed without guidance. If this particular phase of educational activity is not to be eliminated, it places upon the instructor the requirement that he stand before the student as an unmistakable representative of creative work, and as illustrating in his personal attainment the end or purpose of his effort. Evidence of any other attitude on the part of the instructor will make useless whatever attempt he may make to serve as a leader or adviser in the field of constructive study.

The third contribution of value (*c*) furnished by research related to education concerns the immediate use of the results of this study

by the community. While the university is naturally assumed to be primarily an educational institution, it has been made clear that without continuing research it can neither provide adequate instruction nor maintain its leadership in the educational work required. Constructive problems in all departments of investigation must be continuously the subject of successful handling, and the results of this work will be products of the first importance to the community. It is natural that to such an institution the whole people will look for the appearance of new ideas of broadest significance and of practical value. It is to be expected that the state will depend upon the university for information and will expect it to furnish the necessary knowledge and the constructive ability required in meeting new situations that make necessary the building of new plans of thought for community use. The contributions made by research in these institutions will generally tend to concern fundamental subjects and to group themselves on the more indefinite areas along the borders of knowledge, but it is frequently these broader principles which offer the largest opportunity for real addition to the sum of immediately useful information.

The fourth reason (*d*) for including research as a part of the necessary programme of an institution of higher learning involves one of the distinguishing characteristics of the university. By reason of the extraordinary scope of interests represented in such a body, one might expect the unusual opportunity for contacts of investigators in related fields to produce new combinations of formulae, and through these the opening of new fields of discovery. No other organization presents the same wide range of subjects represented by leaders of thought who are normally investigators. To these conditions the university adds an unusual freedom of opportunity for choice of materials or combination of materials to be used in investigations, as also the stimulating influence of a continuous stream of students with new inquiries and new ideas. In no other type of institution engaged in investigation are the chances greater for contribution in fields representing either new groupings of subjects or areas which have thus far remained untouched by the workers of all organized departments of knowledge.

For all of the reasons that have been presented research has now an established place in institutions for higher learning. The position of constructive work in the universities is clearly not accidental but relates to the generic characters of these institutions.

To the university viewed as the highest training school, investigation becomes as necessary for natural activity as eating and assimilating are to continued effectiveness of the biological organism. The research so necessary to continuance of adequate instruction we come to recognize as a normal part of the life of the institution, and we look to this kind of an organization in the course of its growth to produce much of value in the forefront of discovery and construction.

The university fails of its mission in creative work in many instances because, of all the types of institutions, it is the most imperfectly financed for this phase of the work which it should naturally conduct. With the clear requirement that, to keep its position in the first line of advanced thought, it must consist of men of the best type in the professions, the university is often financed almost exclusively for teaching and administration without reference to research, and it is assumed that the constructive work so necessary to development of the faculty and students will be cared for in other ways. Beyond funds for purchase of books, departments with large salary rolls for instruction often show almost nothing for constructive work. The ultimate result of this policy must be failure to attain the full measure of efficiency. Potential leaders in the faculty will either find support of their greatest contributions to knowledge outside the institution, or failing in this they will burn out like a lamp producing feeble light by burning a wick to which no oil is fed.

The university, then, takes its place with other groups of research agencies of the country as an institution caring for the initial training of nearly all investigators, and particularly given to wide range of investigations among a great variety of fundamental subjects. Its activities in constructive work will often run parallel with those of other kinds of organizations, but breadth of interest, wide range of contact, unusual freedom of relationship, and spontaneity will always be among its characteristics.

ADDRESS OF WELCOME TO THE DELEGATES ON OCCASION OF THE INAUGURATION OF DAVID PRESCOTT BARROWS, MONDAY, MARCH 22, 1920

Like other institutions of learning on the West Coast, the University of California is set off in a peculiar class distinguished by its isolation from the great centers of educational activity of the East, as also by the unusual conditions of its immediate physical environment and the exceptional nature of its outlook upon the foreign countries which are our nearest neighbors to the west.

The earlier years of this university naturally saw here the evolution of peculiar customs, and a distinctive manner of thought, the growth of which was directed by the influence of an unusual environment in which we have developed without trammel of habit or tradition. Out of these first years came the origin of much in our life that is characteristically pioneer, Californian, and Pacific in our cast of mind and habit of learning. The sum of these qualities is an individuality not less clearly marked than that of Harvard or Oxford: an individuality giving expression to freedom and vigor of thought such as one might expect in an institution situated on the frontier of civilization in surroundings distinguished by great contrasts of topography, climate, and vegetation. Under these conditions there developed here the philosophy and natural history originating with Joseph Le Conte; the agricultural chemistry of Eugene W. Hilgard; the Spanish-American studies of Bernard Moses; and the school of metaphysics and philosophy led by George H. Howison.

With the coming of Benjamin Ide Wheeler in the last year of the last century, the University was connected with the life and scholarship of eastern United States and Europe more closely than in its early decades, and the influence of a great organizer and builder in the field of education gave us more fully the form and thought of the American university. In this administration came also rapid

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growth of the faculty, submerging the small group that had represented the standard and type of this institution during the first stage of its life. The University came to be more American, though not less Californian, and with this broader outlook it took a larger place in the affairs of the nation. But the influence of environment is cumulative; with the passage of years President Wheeler was transformed into a Californian, and became a developer of distinctively western creations arising from our freedom and initiative.

With added experience in peculiarly Californian problems, President Wheeler saw the increasing importance of our geographic position—a situation keeping us inseparably bound within the structure of the great American nation, but permitting us to develop a vigor of body and mind possible only in the protection of an isolation among natural surroundings of unusual stimulative influence. He saw also the great opportunity of this location as one of the vantage points from which America looks out toward the greatest and most populous of continents. It is not without significance that our honored President Emeritus is today in the Orient on a mission of coöperation concerning America and a great Asiatic nation.

The two periods through which the University has passed mark, *first*, a stage of development of individuality distinctly local in origin; and a *second* stage distinguished by closer relationship to American ideals of education. Upon these ideals there were built characteristics that are generically American, though specifically Californian, and show a beginning outlook over the broader field of world interest in the Pacific region.

And now, following upon the natural steps of our development in size, in knowledge, and in vision, we come to a *third* stage. In it we enter upon an administration characterized by the presidency of a man distinguished as a Californian and an American, but whose field of active interest in science, in education, and in politics, has related itself especially to the problems of the Pacific in the wider sense.

The Regents of the University have therefore considered it desirable that the entrance of David Prescott Barrows into the duties of the presidency be made the occasion for directing special attention to certain of the most important relationships and responsibilities of this institution, especially those which concern our

wider view over the Pacific region, next which we stand, and for the knowing and the interpretation of which no other American institution can be held responsible in larger measure.

It is significant that the entrance upon this new epoch in the history of the University follows immediately upon the greatest movement of all time for international organization, an effort now slowed down almost to halting, largely by reason of inadequacy of knowledge of the world as a whole concerning the real issues involved. Never before have the woefully narrow limits of organized information on world questions been so clearly defined, and never was the need so great for unselfish men with a knowledge of this field perfect in its simplicity and complete in its comprehension of detail.

On the map of the world there are areas in which uniformity of topography and climate, of economic products, racial characteristics, language, and culture prevent contrasts of peoples, and therefore diminish the possibility of conflict in human interests. Regions of marked contrast, like the Balkans, are danger spots, in which continued prosperity and peace can be obtained only by full knowledge and realization of the elements of danger, and by unselfish application of the fundamental principles of human government.

Among the distinctive areas which must be set off on any map we must include the Pacific as a region showing unusual extent of physical uniformity, but bordered by marked contrasts in physical features and in human life. In the past, this uneasy ocean may well have deserved the name Pacific in the human sense—as it has assured peace through the magnitude of the barrier intervening between the bordering peoples, however sharp the contrast of their interests. Recent years have seen this ocean contract as means of communication have advanced, speed and capacity of ships have increased, foreign trade has extended, and national interests have touched more and more closely around the world. Today we see the Pacific with its once widely separated bordering peoples brought nearer and nearer together, until the great barrier is in considerable measure removed, and nations long separated, and with naturally divergent aims, are thrown together. With this closer contact there comes increasing need for mutual understanding among the peoples concerned; and the Pacific, from a region marking a gap between two edges of the world, becomes an area of prime signifi-

cance in international affairs. In this time of world adjustment, when what concerns one nation touches all, we must recognize this area as presenting one of the most important phases of the ultimate problem of world organization. That the mutual help which now obtains among the nations of this region may be maintained is the prayer of all. But this future peace is in the keeping of knowledge, for not in power alone lies the guaranty of stability.

Nowhere should the broad view of the whole problem of relations among these peoples have clearer expression than in great educational institutions, representing as they do the widest range of organized knowledge and the leadership of thought in every field of inquiry. It is therefore fitting on this occasion to place before the delegates of educational institutions here assembled, the suggestion that a very large measure of responsibility rests upon us jointly for mutual support in the nations and peoples that we represent, in order that we may maintain prosperity and peace, which alone permit advance of science, art, culture, philosophy, and everything for which education stands.

There are reasons for believing that organization of every university as an instrument for special consideration of these greatest questions would go far to assist in the continued advance of that kind of knowledge which we must be continuously assembling upon the matters fundamental to harmonious development of the diverse national and social units of which the world is composed. The affairs of other nations may have seemed not to be our concern, but recent experience has shown us the expense of such neglect. No institution which fails to prepare both its students and the community for real understanding and competent handling of the next great world issues can be considered as deserving a leading place in education and in constructive thought.

The University of California has had set before it for several years need for adequate organization to bring the institution to function as a whole on the intricate problems of international relations. In the hope that an outline of this experience may bring your assistance and coöperation in furtherance of a larger plan, I may be permitted to present it in briefest terms.

The University first came to realize fully the significance of the world problems finding their expression in the Pacific through consideration of the plans for the Panama-Pacific Exposition of

1915. It was then that we saw clearly the function of the university as an instrument for work upon such questions. In planning for the Exposition the views of our educational institutions were in part realized through scientific conferences, largely attended by delegates from many foreign lands. In these gatherings the foundations were laid for future international coöperation reaching into many fields of knowledge.

Following the Exposition, in November, 1915, the Academic Senate of the University of California gave consideration to certain problems concerning the wider relations of this institution, and adopted a resolution proposing that "this University give increased emphasis to the work of instruction and research in problems of international and inter-racial relations; and that a committee of the Senate be appointed to formulate a plan for organization and expansion of instruction and research, having the definite purpose of assisting in promotion of amicable world relations." The committee appointed to carry out the plan proposed in the resolution of the Academic Senate reported in September, 1916, in part as follows:

"Your committee is also impressed with the magnitude of the area in this field over which it has not been possible to extend the activities of this institution. It is evident that a large part of the materials necessary for adequate judgments on international questions of greatest moment and of especial significance to the Commonwealth of California have, in proportion to their ultimate importance, much less adequate representation in the sum of our available knowledge than do many other matters assumed to be of immediately practical significance. Your committee feels that at this time of world upheaval, no problem overshadows in importance that concerning the relations of this country with its neighbors. We assume that, however great the capacity for wise and accurate judgment, proper adjustment of our national position to changing conditions cannot be made without full and well organized knowledge concerning the real viewpoint of our neighbors. This must include a wide range of information relating to the environment, history, attainments, social institutions, and ideals which together determine the attitude of nations.

"The committee holds that no institution is better organized for assembling, comprehending, and organizing the knowledge required in solution of international problems than is a university; and that upon no institution rests a larger share of responsibility for understanding international problems of the great Pacific area than is placed upon the University of California. This faculty should be one of the principal sources of knowledge and authority on this subject.

"As an initial suggestion prompted to support work now in progress your committee recommends that all departments concerned with courses touching ques-

tions of international relations in the Pacific area consider the possibility of increasing the emphasis on such instruction with a view to making this work more largely available for general culture and information, and also with a view to making it a basis for work of graduate students.

"The committee recommends as a provision for support of research work in this important field, the establishment of a chair primarily for research in international relations, the appointments to the position to be for limited periods only, and the selection of the appointees to be determined by evidence of ability in constructive work on international problems. It is recommended that this position be used according to circumstances either for members of this faculty deserving opportunity for intensive investigation, or for other persons whose interest and influence might contribute to our thought, and to the sum of available knowledge. It is further recommended that this professorship carry with it a fund for research expenses not less in amount than one half of the professor's salary."

The report of the committee was adopted by the Academic Senate and was considered by President Wheeler for action as early as possible, while the committee was continued with increased membership, in the hope that we might realize some of the objects of the committee's recommendation to the Senate through reorganization of the University's curriculum.

Before the provisions of this report could be carried out in full America entered the World War, and the interests and strength of the University were immediately engaged in urgent matters of preparation for the part which we were to play. The members of the faculty especially concerned were widely scattered, and it was not until the close of the war that the International Relations Committee assembled again with the membership of the pre-war period. At the present time the committee consists of fifteen members, representing all of the departments of the University particularly concerned with international problems, and through the support of Dr. Barrows as head of the Department of Political Science, a Bureau of International Relations has been arranged to relate itself to this larger University group.

On the occasion of our fiftieth anniversary in March, 1918, the University celebrated its birthday with a programme in which the fifty years of history were taken as a basis for consideration of the future constructive work of this institution. The central theme of the celebration was the place of the University with reference to world affairs, and especially with relation to our interest in the problems of the Pacific. On this occasion the Committee on Inter-

national Relations called a series of twelve conferences on questions covering history, international aspects of the race problem, international relations in science, oceanographic problems of the North Pacific, biological problems of the North Pacific, problems of agricultural education and research, international aspects of trade and commerce, and international problems of education. These conferences were largely attended and the discussions, now published, contributed much of interest and importance to our knowledge of the wider relations of the University. Of especial interest were the addresses by delegates from other countries bordering on the Pacific.

The most recent activities of the International Relations Committee have concerned a review of the curriculum of the University with special reference to topics involved in the study of international problems. At present, a wide range of courses on these topics is offered, but there is need for still more organized work, in order to present to students of international relations full opportunity to know the field with which we are especially concerned.

The committee has also organized, and now has in progress, a series of lectures by eminent authorities on international problems of the Pacific; the assembling of this material in book form will mark a real contribution to this field of thought.

What the University has been able to accomplish in the international field is not large in comparison with what might be done. We realize that this can be only a part, though an important element, in our whole university duty. We need now especially the coöperation of other educational groups, organized for the same purpose. However large the significance of societies and other similar organizations, the universities have especial value in this connection, representing as they do the continuing uninterrupted influence of a great and versatile body upon a constant stream of youth which will control our future international policies.

Every true university man must then look forward with pleasure to the opportunities of the epoch which this University with others is entering. We see a time in which knowledge derived from every field of study and investigation will be brought to bear upon national and international problems of economic and political organization overtopping the dimensions of any which we have heretofore faced. The worth of the college and university in assembling the materials needed, and in judgment upon theory and practice, has been proven

beyond question. The field open before us in this western region invites the man of action. The President who now takes office in the University is such a man, and he has given himself especially to the wider view. We believe that under his leadership this institution will serve its purpose in the evaluation of evidence upon questions of critical meaning among the nations.

It is with these thoughts uppermost in our minds that the delegates here today have been called together. The University is honored by the presence of representatives from a great group of sister institutions in our own and neighboring countries. We know that our problems are yours. We realize and appreciate your interest in our welfare. We welcome you to participation in this celebration; we bespeak your coöperation in this great task, which rests in large measure as a joint responsibility on educational institutions. Upon this work will be based not merely the knowledge of our future teachers concerned with world affairs, but future statesmen and executives will depend upon it to aid in guarding the natural right of humanity, as individuals and as groups, to live and grow into the largest usefulness compatible with the freedom of all.

THE RESEARCH SPIRIT IN EVERYDAY LIFE OF THE AVERAGE MAN

Research has been considered generally as a phase of effort quite distinctly set off from the natural course of human interest. It is my purpose to discuss the spirit or attitude of investigation as normally involved in the everyday working plans of the average person.

Of the significance of research in all fields of our endeavor the extraordinary advances and applications of science in the recent war have not left the world in doubt. For nearly half a century Germany had been known as a nation given to investigation in a great variety of little explored subjects, and governed in considerable measure in accordance with the results of such researches. The strength of German military organization, backed by scientific and economic interests welded into one powerful instrument, brought to all the Allied Powers full realization of the need for a supreme effort of intellect in many kinds of scientific and economic operation previously unknown. The result of this reaction was a stupendous contribution to application of research. Incidental failures, due to unpreparedness and to lack of organization, may not detract from the importance of what was thus produced.

No less clear is now in post-war reconstruction the evidence of need for entirely new views of old knowledge, for immediate answer to old questions not yet solved, and for quick results of investigation on problems of construction never before encountered. As had been predicted, we find ourselves to-day going forward to new plans of human organization, but more unsatisfactorily prepared for the complex situations of the new era than we were for the more narrowly limited and clearly defined issues precipitated by sudden climax of war. Conflict such as that through which we have just passed intensified interest and brooked no delay in judgment.

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Reconstruction under peace conditions sets no precise time limits for its decisions. Therefore, we face to-day the settlement of great questions upon which the future of the world depends, but without that definite intention of judgment called forth by the immediate urgency of war-time crises. Our need for solving present vital problems requires a clear understanding of what the questions are and a determination of the responsibility for their solution. While we may assume that this responsibility rests more heavily upon some than it does on others, it is my purpose to call attention to the part which all thinking people have in the movement to bring these great issues to settlement.

In order that there be no misconception of the views presented, it should be clear that the interpretation of research in this discussion comprises not merely the detailed investigations of fundamental scientific principles, but with this includes all inquiry which may be included within the range of thought leading to constructive action. The mere acquisition of knowledge does not contribute unless it is carried on in such a relation that it leads ultimately to the process of building. On the other hand, construction cannot go on without the process of investigation, as each new building operation involves an individual problem to be solved.

Some one has said that much of research—with the accent on the "re"—may be so called because after completion it becomes necessary with much labor to search it out again when real opportunity for use appears. Work of an investigational nature carried on with the right spirit, and with proper organization, should be planned to find its place without great loss of energy or time, or at least be located where, with other building materials, it lies at hand ready for use as required.

The research spirit represents a reaching out to understand and use all that lies about us. Its expression is as natural to a thinking mind as hunger is to stomachs. Its origin is by some compared to an awakening—in which we recognize the world of things about us but have come as yet only partially to know it. I prefer to think of it as identified with the growth tendency inherent in biological organisms, which may carry us on and on without limit, as our powers and range increase from age to age. Constructive work is inseparably a part of the living of intellectual life.

Much of misunderstanding that arises generally regarding the

function and place of research relates itself to false conceptions, *first* of the limits of the broad field of knowledge, and *second* of the degree of stability in nature and in man as an outgrowth of the natural world.

An astonishingly large percentage of the human family conceives of available knowledge as comprising nearly all that may be known, and including much not worth knowing. Such views are not limited to uneducated persons, but have been found among scientific men accepting as final all present fundamental theories of the nature of matter, origin of the earth, relationship of life forms, and other equally critical interpretations of the natural universe. It has required the shock of many recent discoveries in physics, chemistry, astronomy and biology to make clear the fact that our understanding of much that is nearest to us is only imperfectly formulated; and that in the present period we can be assured of a field of the unknown, but not unknowable, about us so vast that realization of our ignorance makes us look only with humble pride upon past accomplishment. To such a field for endeavor as I have remarked for science there may be compared similar regions in the economic, governmental, and cultural subjects, toward which not only the student but the man of business and of affairs looks out with strong desire for attainment of much in knowledge that has not yet been reached. In our day the research of business on scientific lines bulks large in comparison with non-applied science, and present accomplishment has only stimulated the desire for further advance. Every evidence that we have indicates the wide open range for discovery of new principles and new applications of knowledge in practically every field which the intellect explores.

In an attempt to understand the need for continuous research activity, an acquaintance with the order of stability or instability in nature and in human affairs is hardly less important than a conception of the relatively narrow limits of attained knowledge. Human beings seem curiously inconsistent in that though they are stunted individually without constant growth or change, they attempt to deceive themselves into belief that an unchanging situation is the normal condition of nature. We calculate an average rainfall and expect it to rain just so many inches, be it 24 or 46 each year. We are shocked if it rains less. We see the rocks

distorted and torn by countless movements dating through all past periods of earth's history, but we are surprised when a slip of a few inches disturbs the seeming present-day stability and produces an earthquake. We build highways of concrete and are astonished that they wear out. We write constitutions and expect the judgment of the men who made them to fit all times and conditions. Yet history shows us that with the law which states that nothing is completely destroyed, we must write with Pythagoras that nothing remains continuously the same. The geological book—the greatest historical document of all the ages—gives us as one of its truths the fact that in the known hundred or more million year record of life, nothing has remained in constant form; that the rule has been not only continuous change but also continuous advance of the highest level. Through vast periods man has himself been subject to changes like those that have been expressed in other living types; and the habit of nature so set forth seems to indicate that with the earth in continuous state of modification we may expect life and man to keep for the future a rate of growth not less rapid than that of past ages. Assured of the validity of these principles, we can be certain that as a race and as individuals we shall be almost continuously under the necessity of meeting adjustment and readjustment to new conditions. We have to face not merely the question of new knowledge which research should secure for the use of the moment, but with this we must have understanding which will guide and support us in the continuous movement incidental and evolutional which must be looked upon as the natural order.

With realization of the unattained limits of knowledge, and with the conception of continuously operating growth and readjustment to which we as individuals and as groups are subject, there comes to every person an understanding of the necessity for continuously operating constructive work. The giving of such a view as has been suggested is in my interpretation a necessary part of the broad function of education.

Education should not only give the wider and deeper view of the structure of knowledge, but with this it should furnish an acquaintance with the methods by which knowledge is obtained and applied. By one classification, educational work may be given five great purposes: (1) To determine our individual capacity for knowl-

edge, and adaptability to special subjects; (2) acquisition of facts; (3) learning quality of judgment and organization of materials; (4) developing power to construct or create; (5) forming of character and development of altruistic motives. Education often concentrates itself on the acquisition of knowledge or of facts organized and unorganized, neglecting in considerable measure questions of capacity, training of judgment, constructive ability, and the development of character. Not without significance is an illustration in a recent publication representing a student with his arms piled full of books marked "knowledge," but unable to accept the volume of "wisdom" or judgment offered to him.

The third and fourth of the five points mentioned in the classification of educational aims, namely, judgment and creative ability, are in a large measure representative of research. Though based upon the accumulation of facts, the critical significance of research lies in the quality of judgment and organization leading to constructive use, with the ultimate goal of application or service. One of the greatest contributions that education of the future can make is to place the emphasis in training on a broader view of organization of knowledge, on the ability to judge and construct, and on the desire for service. Not until such an understanding of the function of educational training comes into general acceptance, can we expect the average man to be brought into full participation or interest in the spirit and opportunity of the constructive work of the world required from day to day.

It is, I believe, also a responsibility of the educator to bring about a better understanding of the relation between the two great ideals of *construction* and of *service* which are fundamental to the philosophy of right living. Two groups of persons who contribute greatly to advance the comfort and happiness of mankind are, those who produce the new ideas upon which we build from age to age, and those who give themselves to public service in the larger sense. There is in my judgment a close and necessary connection between these two types of relations to the community. Research should lead to construction and is not complete unless the results are available for general use; while public service rarely attains the purpose for which it is initiated unless it is distinctly constructive.

I have spoken up to this time of the broader view of research, and of its more general relation to great problems with which we are

confronted. In considering specifically the connection of this phase of thought with the life of the average man, we should look more particularly to the practical value of constructive work in contacts which may be considered representative of everyday life.

Research or constructive work is often divided into two types, one concerning fundamental principles without regard to their immediate application; the other, sometimes designated as research of application, representing especially the investigation of methods by which principles already known are put to human use.

The first type of investigation has been advanced especially in institutions concerned particularly with scientific and educational problems. Much fundamental investigation has, however, been conducted by engineering and governmental laboratories established specifically for the purpose of contributing to clearly determined needs. Through acquaintance with any one of many occupations such as agriculture, engineering, or business, the average person is sooner or later intimately in contact with some phase of this type of research.

Research of application reaches its highest expression in the great engineering laboratories of corporations recognizing the possibility of drawing from the field of investigation uses of scientific laws or principles, which may make possible great saving or higher efficiency in the conduct of their business. Enterprises organized for legitimate gain do not always make increased income by increased profit percentage, but often by increase in volume of business, introduction of new materials, or utilization of new ideas. Volume of business may mean increase of plant. The use of new materials often means a practical reorganization of plant and increased expenditure. Introduction of new ideas may mean increased efficiency, increased profit, and, with the exception of purchase of patents, may not require continued increase of expenditure.

Research of application finds general use in the problems of everyday business and everyday life, in which we are forced to make decisions which lie between following rule of thumb methods and the possibility of making a special judgment for every situation which confronts us. It is the difference between the attitude of the oculist or optician who has just so many possible standard types of cases into which all eye troubles can and must fit, and the other man who, under normal circumstances, considers each eye as differ-

ent from every other and judges it specifically, according to the fundamental laws of physics basic to his subject. It is the difference between the type of housewife who makes all pies in California according to the rules used by her grandmother in Maine, regardless of the character of the flour, or the kind of fruit; and the other housewife who, according to the materials involved and the end to be attained, judges through experience and experiment the combinations most acceptable.

The average man of intelligence comes to recognize in the course of his thinking that he lives in a world which we understand only imperfectly. At every turn he encounters the limits of his own knowledge and of our total accumulated store. In every kind of business or occupation he moves among those concerned with attack upon problems which are new in the general as well as in the individual sense. In some small part he is called upon to help in the solving of these questions. He is also expected to know how to secure information on problems which he needs to solve. In a still larger way he must understand the movement toward solution of economic and governmental questions, in order that as a citizen he may exercise his privilege of giving intelligent support to those whose special work it is to investigate these matters and to pass judgment upon them.

It is part of the duty of the average man to know the difference between pernicious questioning and constructive thinking; to judge what things of the established order should be left alone and which should now be changed. He must be a conservative, standing for stability, and yet recognize the constitutional evanescence of all things natural and human, and stand for progressive movements at critical times.

The average man must learn to know and value the contribution of the specialist or expert in constructive work, and call into his service men representing fields other than his own particular province. The habit of requesting properly organized investigation must be developed and put into operation in directions which show promise of leading to results of importance to the community interests.

The average man will do his research mainly in the field of application, rather than in studies of fundamental principles, but he will find the pleasures of constructive work outweighing in realization all

other types of enjoyment. He will discover here a continuing interest which leads on with undiminished attraction and brings renewal of life stimulus.

As opposed to the life of constructive type, we may visualize the conservatism of habit in those individuals who fit themselves into the treadmill cycle of custom. Their individuality wears down to nothing, and they become only cogs in a machine of which neither the structure nor the purpose is seen. On the other hand, the constructive life means not alone continuous growth and unending youth, but it offers as well the largest opportunity for enjoyment of service. It furnishes the basis for that reaffirmation of individuality which both in science and in human service has been characterized as being born again. One who constructs and accomplishes sees new life. Those who follow blindly and without individual vision are sometimes known as of the practical type, and not infrequently pride themselves on refusing to accept the new which may be good and perpetuating in their life work the errors of their grandfathers, which the grandfathers would not thus have carried on.

Research and advancement of knowledge in the future depend not alone upon expressions of individual genius, nor upon opportunity for concentrated investigation in limited fields. The intelligent use of results of constructive work by the people as a whole, a general understanding of the methods by which this information has been obtained, and a knowledge of the means necessary to support research are also indispensable. Great advances of the future are not dependent upon having every man do everything as an expert, but they will rest upon a wide appreciation of the importance of constructive thought, of organized knowledge, and of the need for continuous advance of knowledge.

Education will play a large part in the support of research through giving, even in elementary courses, the proper view of knowledge and an understanding of the means by which it grows. Nothing would probably go farther toward bringing us to a satisfactory view of our present situation than a course of instruction on that which we do not know, but which might by investigation become known. With this there should go a presentation of evidence as to the methods by which constructive work could bring this information and apply it.

A great responsibility for realization of the possibilities in education rests upon those scientific organizations which have given themselves especially to the problems of constructive thought. Through the scientific institutions which we represent, it is our duty to make clear the function of education to train in judgment and construction rather than to encourage merely the amassing of facts. A responsibility rests upon us to see also that the results of our own investigations are not buried more deeply than were the materials upon which they have been based. New ideas should be clearly recognized, fully stated, and placed where the applying engineer may find the data which he requires to meet human needs. We have again a duty, so to organize our work that other investigators and applyers may not only know the results, but that they may cooperate with us to mutual benefit.

There is no doubt that properly organized and coordinated efforts of science and education may increase greatly the present opportunity of the average man for constructive activity, making his life more useful and happier. The average man of the future will of necessity live his life largely in a routine based upon customs of the prevailing social order. He will give himself to action governed by established rules formulated from experience; but always and increasingly in his individual affairs, as in his relation to the community, he will find his largest measure of satisfaction in the building type of effort originating through his own thinking. As the product of the life work of each individual accumulates, the evidence of true individuality will become more clear, until there emerges from the chrysalis stage of mere physical and mental separateness the newborn personality of one who in creating an idea has given to himself the right of eternal individual recognition as an intentional participant in human progress.

As the problems of community organization become more clearly visualized, the importance of the research or constructive spirit in the average man will increase, and the future of democracy depends in a measure upon the possibility of securing for each capable person an opportunity to obtain the wider view of the greater problems, to learn dependence upon those who know and are true, and with all this to make contribution in an unselfish spirit. Unless these objects are realized we are doomed to revolve without progress through endless cycles of misunderstanding and conflict.

Education with its varying emphasis on the fundamental truths of science, philosophy, human relations and religion is our principal safeguard. Our definite guarantees of progress are found in the lessons of history, taken with the present wide expression of individual responsibility for judgment in the critical affairs of citizenship.

COMMON AIMS OF CULTURE AND RESEARCH IN THE UNIVERSITY

By definition universities aim to compass the whole range of knowledge. In practical operation they are characterized rather more by diversity than by unity of effort. It is in the nature of things that bodies so constituted should attempt to express the various phases of thought represented through many kinds of organization, and we expect to see philological, chemical, biological and other types of clubs or societies forming a normal part of the machinery of every great educational institution. According to the particular interests of the moment these agencies within the walls group themselves in different ways to accomplish specific kinds of service.

The most interesting of all organizations peculiar to the university are the two widely inclusive societies representing scholarship or culture in Phi Beta Kappa and research and science in Sigma Xi. These two bodies express in their aims nearly the whole range of higher purposes of academic effort. It has seemed to me that a study of their interrelations, extending to a redefinition of their common objects, might help to set forth that continuously needful statement and restatement of the reason for existence of institutions of higher learning. Inclination to consider the purposes of these societies has been particularly strong as the course of my life has carried me into contact with research and education in such a manner as to bring into close relation, and yet into striking contrast, the types of academic mind which we call scientific and humanistic. Having seen these interests so frequently defined with special reference to their separateness the desire has grown to secure a better understanding of their true relations.

Although recognizing fully the specific aims of scientific and of humanistic investigation one can not avoid being impressed with the importance of considering the similarity of their methods and

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purposes. It is particularly desirable to consider this interrelation as a great group of thinking people still holds humanistic and scientific problems so different that common criteria may not be used generally in their solution.

Scholarship and culture as they are involved in the aims of Phi Beta Kappa have been considered often to represent a goal quite different from that toward which the scientific investigator strives in Sigma Xi. Scholarship should mean understanding and wisdom, not merely information. Culture has been taken to represent refinement of educational attainment and appreciation of knowledge, coupled with the development of personal characteristics giving that balanced judgment sometimes known as mental poise. Culture should furnish perspective and interpretation. Its perspective should make it possible to fit into their proper relations all available facts and to determine the position which new knowledge should take. In its truest expression it should be active and not passive, constructive and not absorptive. The imitative spirit is its greatest danger. True culture is a comprehensive vision and an attitude of the active interpreting mind.

Sigma Xi was organized to promote comradeship in research. Its activity has been limited not infrequently to the so-called natural history subjects. I am unable to conceive of this organization as functioning logically if it does not cover the whole range of investigative or constructive thought in which the scientific method is used. I think of it as standing for development of the attitude of mind which produces the builder, rather than for conduct of specific researches within a limited field.

Research has been defined as a reaching out to bring together, organize and interpret whatever may be added to our store of knowledge. It may express itself in the most intensive studies in very narrowly defined regions, but is most truly exemplified when it involves the wider relationship of specific facts to the whole structure of knowledge.

In the processes of research it is difficult to distinguish between those operations which are merely the gathering and those which are interpretation and definition. Simple collecting of materials without giving them their proper places and without interpreting them is work of a relatively low order and is doubtfully classed as original investigation.

By definition the present discussion is limited to relationships between culture and research as expressed in the university. A clear understanding of my purpose, therefore, involves recognition of the real aim in university activities. Without intending to offer a complete classification of the objects and plans of educational work it may be well to set forth the following as representing some of the aims of university life. These are, first, to hold before young men and women the mirror of knowledge and experience in which they may be able to see reflected the qualifications which fit them individually for this or that profession; second, to give classified information; third, to develop wisdom or judgment; fourth, to stimulate the growth of constructive or creative ability; and, fifth, to inculcate the element of character, which defines our relation to the world of human life. The highest aims of education are far from being generally understood. Many still think of this agency as informational rather than constructive, teaching imitation rather than initiative, and as focussed upon the past rather than the future.

One of the most fully valid criticisms of university study lies in the fact that too often it looks backward without adequate expression of relation between past and future. The young men and women who form the student body are at that early stage in which they have practically no past and naturally live in the present and future. Their eyes are turned forward with keen expectation of what the coming years may bring. Life and movement of life are to them the supreme enjoyment. Until their individual pasts begin to evidence marked effect upon the trend of their futures, uninterpreted history and experience represent to them only shadowy forms or objects of ill-defined curiosity. Quite in contrast to the ideas of youth the machinery of the university may lend itself to too strong emphasis upon what is behind us. Thus educator and educated seem to look in opposite directions, and like Lot's wife, who "looked back from behind him," the educator may become as lifeless as a stone or fossil without sensing the change, while the company of youth moves on.

With a well-ordered program of university work, development of constructive ideals in the student inevitably carries with it in the scientific studies an unlimited series of questions regarding the relation of each element of nature to other items or forces, and requires

recognition of continuity or law through all space and through past, present and future. Similarly in humanistic study the ideals of conduct and character come to rest upon realization of a continuity of interests and responsibilities in the world of human life. These ideas of interrelation, which may in one sense be called law, are necessary to the clear expression of both research and culture. Scientific understanding of nature depends upon our realization of the continuity of its principles of being and action. The meaning of what is covered by culture and scholarship we shall not know adequately until we understand the interrelations of events in the history of human institutions.

Large use of the principle of unity is essential if we would succeed in attaining the ideals of education either in science or in culture. The university programs which have greatest value are not prepared for the immediate future of the student but concern rather his activities at the time of maximum effectiveness. If the student's life be of normal span he graduates near 21 and his period of greatest value to the world lies between 35 and 65, or from ten to forty years after graduation. If the many years of education are to count in the stage of most fruitful service, the work must be carefully planned for attaining this end. It should be clear that the most valuable information which the student carries away is not comprised in the immediately practical things for use to-morrow or the next day, but in the basic principles and methods which in later years will help to answer the new and critical questions certain to arise, and in the answering of which there will be the largest opportunity for personal development. The details of specific studies in university experience are largely lost, but the attitude of mind resulting from honest thought, and the elemental laws which furnish the foundation for all constructive work will be of increasing importance.

From the point of view of culture and also of science the subject of history is one of the greatest of all agents for making possible our understanding of the principle of continuity. History has not too often been considered a science, although in its effect upon the human mind its operation is almost identical with the idea of continuity or unity in physical laws. It has had too small a part among the great opportunities of humanistic education. Oddly enough the tritest phrase growing out of this study is that "history

repeats itself," and therefore we seem only to be studying a past which in effect may be repeated in the present or future. But what is it that history repeats? In addition to the idea of continuity, the most evident things coming out of historical research are that history expresses two almost unvarying principles, one, instability, the other, progress; one the view that everything is subject to change; the other that this instability includes in its operation a general movement toward what is more complex and in the realm of intelligence toward fuller comprehension and understanding. I am willing that this statement be challenged, and shall not attempt within these narrow limits to give it full defense. It may only be remarked that if this view be accepted there is no greater lesson to teach a student than that, contrary to commonly accepted conservative views, the future in which he will live his life will not be like either the present or the past. The direction of movement in the future may, however, be indicated by the evidence drawn from a careful scrutiny of history.

In preparation for later life, the well-trained student of history will look forward with a definite expectation of shifting lines, and should be prepared for those situations in which judgment may be exercised either to accelerate or to retard the natural movement of progress. The laws of history show us a normal instability which should be recognized and capitalized. We should expect to interpret the trend of events. The gift of intelligence puts before us the opportunity to help naturally with normal progress. The possibility which increased knowledge gives for greater evil does not mean that evil must therefore be done. It is only an evidence of wider range of capacity. It is scarcely conceivable that with all the consequences clearly understood real intelligence could permit the following of a path that would lead to its own destruction.

It is difficult to discuss the influence of culture in the broader sense upon science and research, or the relation of these two elements with the current reversed; but in the hope that the effort will be understood as an attempt to view the problem constructively, I venture to suggest what seem to be some of the normal interactions.

Let us assume for immediate purposes of this discussion that the essence of research is the attempt to understand, organize, utilize and increase our store of knowledge. The only persons who are not

believers in the value of research are those who studiously keep away from the borders of knowledge. To one who has investigated in any subject our painful limitations are only too evident. The successes of research in every field within the past decade show that the possibilities open more widely with every discovery. One of the most dangerous types of people we may have engaged in handling affairs of moment is that which assumes all useful knowledge to be comprised within the facts already assembled and fails to recognize the possibility of progress in nearly every direction in which we choose to investigate.

Progress in discovery and in constructive thought has increased our social inheritance so rapidly that the luxuries of one age often become necessities of the next. If life is defined as a form of motion, true living in the human sense is a state of motion in which the conditions seem not fully satisfied without a kind of advance which we call progress. I doubt whether happiness is possible without a sense of accomplishment, either individually or socially. Research by bringing a stream of new materials into application serves as one of the most important agents for making human progress and happiness possible.

In order that we may know the materials with which we are to work in the future, education must present organized and simplified knowledge to each incoming generation. In addition to pointing out what is already known it is the duty of the university to indicate the direction in which progress may be expected or desired. It is important that special stress be laid upon the kind of thought and the methods necessary for progress in order that the future investigator may do his part. Among the greatest teachers within or without the university we rank those who have set forth not only what is known but also what should be known and should be done. In general they have shown the way by example as well as by precept and have been among those advancing exploration, discovery and philosophic interpretation.

I believe that the lessons of history suggest continued advance or progress of the human type, both in social organization and in physical being. Social evolution represents an unbroken train of experience and therefore gives the greatest possibilities for accumulation of power and of opportunity to use it. In this type of evolution research is the most effective instrument employed. Phys-

ical evolution is related to replacement of individuals in the succession of generations. Without physical advance the limits set for mental capacity in individuals will mean the ultimate attainment of a level of social evolution beyond which we may scarcely reach; but what I see of history expands my optimism to accept the view that nothing within our horizon of information gives evidence that the final stage of physical betterment is yet in sight. I do not believe that with increasing knowledge we shall lose such opportunity for advance as may still be open to us.

Research in science has suffered severely, both within and without the university, by reason of failure to recognize the magnitude of the field in which it operates and the interrelation of the elements comprised in it. The researcher must, by definition, be a specialist, in that he should understand more fully than any other person the height or depth or breadth of a particular element or law of nature. Narrow specialization is often considered to represent research, and contraction of the limits of investigation is not infrequently desirable. But the greatest specialist does not merely go up high or down deep. He sees from these advantageous positions the real significance of his explorations. If he proceeds far in any direction without interpreting what is learned in terms intelligible to others, the journey has been merely a personal excursion and not a contributing voyage of discovery.

I come therefore to speak particularly of the need for contact between research and culture, in order that the broader human relation of culture and scholarship may bring to research a better power of expression and a deeper interest in its ultimate significance, thus making more useful the fruits of discovery. Research may profit greatly by contact with every human interest involved within the wide comprehension of culture. Much of the material uncovered by constructive work in science has not reached utility or become real contribution to humanity by reason of the view that investigation is complete without interpretation, or that it is an end in itself without regard to human use or meaning.

Science and research have missed great opportunities because of aloofness from the more strictly humanistic aspects of investigation extending into the realm of culture. Problems of research have so multiplied within the field of natural science that there has perhaps been good reason for our failure to discover that the most com-

plicated, and therefore in many ways the most attractive problems possible to the investigator are above and beyond those which have mainly engaged our attention. Important as are the nature of matter, chemical affinity and organic evolution, some of the greatest fields for discovery still relate to the fundamental understanding of human behavior and cultural interests, both in the individual and in the group sense. With adequate cooperation between the scientific investigator and the humanist research should advance rapidly in the study of man and his cultural expression. Investigation of the physical basis of mental action may never produce such results as have recently revolutionized natural science. On the other hand, it may be that human research will go farther beyond our present knowledge than radioactivity has carried us forward in physics. Are we to believe that man, probably the most complicated of all objects or instruments in the universe, may be neglected as the object of research by reason of his high level of development? Is it not clear that added knowledge, such as should be secured by united effort of the scientific investigator and the humanist, would give further control of our powers and greater satisfaction in their use?

It is with the hesitation of one known as a representative of the scientific school that I touch upon the other phase of the problem, namely, the possible contribution of research to culture and scholarship. If I were to indicate what might from my point of view seem a dangerous element in scholarly and cultural studies as contrasted with the situation in science and research, it would be to suggest that there is not in any branch of knowledge a finished chapter or a closed book, and that there is no field in which the principle of growth and progress may not be expressed profitably through constructive work. Culture must in some measure stand for conservatism and precedents. Theology tends by definition to be one of the most rigid of all phases of human thought, but scholarship stands next in rigorous adherence to standard. This condition is natural. Even the normal instability of evolution shows generally a stately and unhurried movement which illustrates the idea of standards in rate of change. The researcher states, "There is more unknown than known"; the scholar says, "We have before us only the known and must therefore base our practical lives upon it."

Scholarship in a passive or conservative position diminishes its value. Culture not merely sets standards of form but may also indicate the rate of progress. It may not only require that we know the best from the past, but should demand the best that can be secured in the present and future. The study of human actions and interests is not to be limited by assumption that creation, even in the human sense, is ever complete, or that existing states of law or culture are final. Science and research should be tied to the humanistic group of agencies for a combined investigation of problems of every kind relative to man. Culture should be a constructive force with the authority of history, and an active source of ideas and ideals.

Research and cultural activities not merely overlap and have common aims, but their highest expression develops through influence of similar types of constructive ideals. The idealism which gives life and hope to culture and science may be academic, unprofessional, or even unfashionable, but it has contributed much toward securing the present privileges of humanity. The practical man insists that he is limited by what is and not by what might be. The idealist dwells upon what should be, with the hope that what is, by reason of its instability and by virtue of the laws of change, may ultimately come to be the thing desired. The practical man with his hands tied by what he *must* do sets precedents and limits which sometimes bind the wheels of progress. The idealist, with the widest view of unity and movement reaching through the universe of being and of thought, visualizes the larger possibilities and helps to sweep away obstacles in the path of advance along lines of natural development.

And so, without further expansion of this view, it is clear that I do not hope to see less diversification in university activity but only more unity. We should represent here every type of thought. We must assemble, organize, interpret and construct in every region over which knowledge may extend. We must have differing types of mind and multifarious points of view. With meticulous refinement of technique some will seek out the minutest details of obtainable information and set them in order with relation to the ocean of available facts. Some will work upon the nature of matter and others on the theory of the state. But with all this differentiation, the principles of unity, or law, and the interrelation and

interdependence of all knowledge should everywhere be recognized and made the basis of advance in thought. The delight in construction and the joy in expectation of progress should be lessons of experience which no one could fail to understand. Culture and scholarship should help science and research to better orientation. The explorer and builder should be imbued with that culture which gives the clearest vision of the road for human progress.

We must not forget that for each individual the end and aim of university effort is the securing of that knowledge which fits him into the niche in which he may perform the largest service; and that the university is not an apprentice shop, but is a source of ideals and a type of environment peculiarly fitted for growth of constructive minds. Let us be clear that whatever the university gives represents wasted time, effort and material, unless it is received in a spirit of reverence and with the idea that the greatest satisfaction lies in service as a builder who does not work for personal ends. It is said that geniuses are born, not made; but those who come into the world to live non-contributive, purely individual lives, leaving the world no better than they find it, we may truthfully say are only made, not born. Contribution to meet real human needs gives perhaps the only way by which we obtain full right of recognition as individuals in the strictly human sense. We may not know why living things must grow if they would live, or why history has given a choice between progress and oblivion, but the thinking world has always recognized the validity of this view.

We remember that the Great Teacher explained to Nicodemus the Pharisee: "Marvel not that I said unto thee, Ye must be born again." With all the spiritual meaning that this saying carries may it not suggest to us also that constructive service gives, with a sense of reality, a new and true life, a verifiable personality in the kingdom of creative beings. What greater work can a university perform than through its vision, its constructive power and its culture to open the way to that kind of service which brings the joy of progress and the continuing rewards of real accomplishment.

Carnegie Institution of Washington

MEDICINE AND THE EVOLUTION OF SOCIETY

In its inception medicine represented the effort to palliate or cure ills already fastened upon individuals. With advancing understanding of value in social machinery there came naturally a development of interest on the part of the community in organizing itself to guard against disease or ill health, and in some measure in protecting itself against the individual. As in practically every form of scientifically planned activity for human benefit, medicine rapidly passed beyond the stage of mere palliation, correction or warding off evils, and became a positive or constructive agency building along new lines where once it sought only to repair or to protect.

Methods and rate of advance in evolution of medicine have varied greatly. The development of a desire to carry proficiency to perfection has produced an art. A permanent cast of open-mindedness has produced research.

Achievements of the science and art of medicine which have made possible modern wonders of antiseptic surgery and of immunization are now followed by efforts aimed toward complete elimination of diseases, as in the epoch-making activity of the Rockefeller Foundation in eradication of yellow fever.

In addition to correction, cure and prevention of disease, much constructive work has been done in bringing our physical condition, at various stages in development of the individual, to a level of effectiveness not known in earlier generations. Research on the eye, coupled with utilization of lenses, gives continuing effective sight. Increase in number of deaths from troubles of the heart and of the circulatory system in general, which seem to come with higher average age, stimulated study of these organs in their relation to physiology of the whole body, with results which may give us new lease of life.

Although its effort must always be directed largely to curative

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and preventive functions, medicine is now in the distinctly constructive stage.

Discussion of questions touching evolution of society implies justification for the assumption that society will continue to exhibit changes of the nature which we call evolution or advance. The human problem is one of many aspects, and I am presuming to examine it, to some extent, from the point of view of one reviewing history in its longer reaches.

We may admit the almost incomprehensibly difficult nature of any study that concerns itself with the future. I am fully aware of the danger of such ventures and that the statement concerning the prophet being "not without honor, save in his own country" should, to wise men, act as a deterrent. At the same time it is clear that for guidance in many of our greatest practical problems there are no aspects of thought more clearly needing cultivation and organization at this time than just those key questions relating to the trend of human development.

To-day as never before the scientific world seems distinctly interested in the future of society. Exceptional stimulation of patriotism during the great war gave us a high expression of solidarity and effective human organization. The post-war period in scientific philosophy carried us to the other extreme, and was one in which literature was filled with reflections of certain aspects of social organization indicating incipient decline or degeneration. A decade of sustained peace has permitted products of constructive thought to accumulate. To-day, with organization of humanity reaching a stage of complexity not heretofore known, it is natural that close attention be given to examination of social movement or evolution and to search for evidence as to the direction in which it may be expected to extend.

The present status of thought concerning broader aspects of human relations is also in part due to a distinct tendency toward emphasis on fundamental philosophic concepts and toward viewing each subject in the light of its most comprehensive expression. The intensive effort expended by the specialist is seen to be of importance both because of the individual facts it furnishes for building and because the particular line of effort which it extends gives another kind of view of the whole structure of knowledge.

The expert in study of spectral lines in astronomy attains a skill

of interpretation that enables him to pass instant judgment on questions concerning temperatures or movement or other conditions existing in vastly distant solar or stellar sources of the spectra. The expert on variation in mice or jimson weeds may fail to understand the distinctions separating types of spectral lines; just as the differences among mice or jimson weeds, about which he talks with such assurance, may be absolutely non-existent so far as the immediate powers of perception of the physicist or astronomer are concerned.

The significance of the situation in science of today is expressed in the fact that the astronomer is using the spectral line to give essential data relating to conditions indicating distance or states of motion, and other factors which concern the nature and structure of the universe. And the jimson weed expert is not so much concerned with the species or varieties of the genus Datura as he is with the principles which tell us something of the operation of reproduction, variation and evolution.

Our tendency to broader generalization and more distinctly philosophic consideration of fundamental law is itself in some measure due to a tremendous widening and deepening of the realms of space and time and movement in which our thought ranges. This expansion has tended more and more to bring about contact or overlap or connection between aspects of nature which once seemed unrelated.

In space relations, astronomy now carries its limits out so far that our solar system becomes only a speck in a vast galaxy of stars with dimensions measured in hundreds of thousands of units each representing trillions of miles. Our milky way or galaxy, with these dimensions, is seen as only a speck in a universe of galaxies of which the farthest fade out gradually to a region where they vanish, not because space ends or the world of universes terminates, but because the one telescope by which we see these remote specks has reached the limit of its power of definition.

In time relations, geology shows us the actual sweep of ages in records that hold the epochs of the past before us in order of their being. Here we see time stretched backward from our day through periods measured in hundreds of millions to billions of years—and yet the reality and meaning of that time, and of what happened in it, is like the present. Paleontology presents the moving current of

life streaming through geological eons, with its marvelous history of development leading through lower forms up to man and on by stages of human progress to attainments of present culture.

As our world of scientific thought broadens and shows more and more clearly the connection between remoteness in space and time and our place in the living present, it is not possible to avoid the formulation of laws which cover also what we call the future.

With knowledge of the universe spreading at prodigious rate to cover time and space, with an acquaintance of the history of life on its march through the ages, with rapidly growing knowledge of the steps by which man has come up through gradually rising stages of physical development and culture, it is natural to inquire whether we are not now in position to make assumptions regarding the future of man and of the social organization which he forms. Can we not make such assumptions with expectation that the attempt to look ahead will help to guide us in judgment on some of our most complicated world problems?

The term evolution of society concerns in reality both what touches the individual and the group. In recent years discussion of advance, so far as it relates to humankind, has shifted largely from consideration of the individual to investigation of evolution in the group and its products collectively.

Organic, or so-called physical continuity, is represented through the succession of individuals. Continuity in the body of knowledge and accumulated experience is represented in society. Man has advanced rapidly in building his own environment. In a sense he has created for himself a new world through accretion of contributions brought by the succession of individuals and of generations, the whole structure being held together by continuing community of interest.

In the purely social sense we are concerned with evolution or advance of methods of organization and with broad subjects, as physics, chemistry, architecture, medicine. Individuals born into this world inherit directly that which is passed on to them in their physical being and in the physical basis of their mental capacity. In the social sense they receive the accumulated benefits of knowledge obtained, organized and protected by preceding generations.

The elements upon which evolution of society depends may be discussed on the basis of many kinds of classification. We recog-

nize advance of this group as dependent upon the common body of knowledge and experience and also upon the capacity of individuals to use these assets. Setting aside for the moment the position of the individual, we may say that advance of the group, or growth of the social heritage, is dependent upon:

(1) The securing of new knowledge by discovery, invention and research.

(2) Unification of knowledge or understanding of the interrelation of its parts; the result being an arrangement in which every item should be seen in its proper perspective or relation to every other item.

(3) Development of adequate means for establishing continuity in knowledge in what we call education of a given generation or in transmission from generation to generation. Failure to have knowledge consolidated in the community by making it common property, or failure to carry the lessons of one period to the next, would mean breaking down of civilization, destruction of the advantages of the social organism, or in a large measure destruction of the new world created by man or society. It is important to recognize that education does not mean merely the handing on of information. It concerns true understanding or appreciation of the materials transmitted.

(4) Advance, development or the evolution of society is dependent upon physical and mental effectiveness of the individuals of which it is composed and upon the time available for their work.

(5) Advance of society is dependent upon continuing betterment of its economic and political organization. No matter how far we proceed in other respects, if the machinery of economic life or the methods of political organization fail to give coincidently adequate expression of individual freedom with the fruits of social cooperation, advance or evolution will be retarded.

(6) The furtherance of social development depends in a very fundamental way upon the possibility not merely of making the individual effective physically and mentally and socially, but upon the opportunity also to strengthen the type or enlarge the actual basic capacity of individuals.

The critical question toward which this paper is directed concerns the function of medicine, interpreted in the widest sense, in promot-

ing movement or advance or betterment of the social organization which man has created. The individual in relation to the course of his life reminds one of the rider of a bicycle. He seems safe only if moving and satisfied only when advancing. Life itself is often defined as a form of motion. So society also demands the joy of change. If Wells's "Outline of History" did not convince the public on this point, the "close-up of history" in Mark Sullivan's study of "Our Own Times" will not leave possibility of doubt.

The world is hungry and thirsty for variety and also for verifiable evidences of progress. It is important to satisfy this demand without periodic resort to revolutionary methods like those of war as means of insistence upon particular modes of thought or action or as an outlet for feelings or as an exalted form of sport. Society has seemed almost regularly to turn from its treadmill round of daily duties into the fierce pleasures of making the world safe for this or that kind of economic, political or religious system. It is essential that we learn the joy of growing or evolving through appreciation and construction, instead of through mere accumulation or by the relatively easy method of destroying something.

It is my purpose to inquire whether medicine, instead of being purely palliative, curative and protective, does not make one of its most important contributions in facilitating and supporting the growth process so clearly essential to society.

As has been indicated, the advance of society is dependent upon two quite different types of evolution: one, the basic element comprised in physical and mental development of the individual; the other, the strictly social element compassed in the accumulation, organization, effective utilization and constructive development of community knowledge. Both features are essential.

One element peculiar to this problem, and to which special attention must be given, relates to the fact that human intelligence recognizes its own place in the world and insists upon expression of individuality in its possessor. The famous words, "I think, therefore I am," might well have been written, "I think, therefore I am independent." We must, of course, not forget that man sees also the importance of society to him. The individual will always assert his right to attention. In any scheme of social organization he is not only the basic element, but he demands the right to live and to

grow as far as his intelligence and desires permit. Society has added the condition that this be granted so far as it is compatible with similar privilege for others.

I have already mentioned six items from the long list of elements upon which the evolution of society depends, if it is to proceed on a basis which will guarantee continuing improvement. These points were made without reference to definition of means by which the needs can be met. For our present purposes we wish to know the relation of the contribution from medicine toward meeting requirements of these points.

The *first* need concerned securing new knowledge by discovery and research through which society would better its situation. These advances must be in all possible fields, and medicine could expect at most to have only a modest part. The contribution actually made by medicine is significant, both as to actual addition of new materials and through the indirect effect upon advance of research in many other subjects.

Out of present-day organization of civilization comes the fact that the applying sciences, as in industry and medicine, have become themselves outstanding research instruments, adding much to fundamental principles of knowledge upon which they have been dependent. Such an institution as the Rockefeller Institute for Medical Research, carrying investigation into the foundations of biological and physical sciences, makes large addition to our basic knowledge.

Indirectly medicine and medical research stimulate enormous production of new information in closely related subjects, ranging from physics, chemistry and biology to economics and political administration.

Toward the *second* requirement, namely, the unification of knowledge, it is again true that the application of fundamental knowledge for specific purposes, as in medicine, leads always to the bringing together of data from many sources. The influence of organization of knowledge for the purposes of medicine makes necessary a redefinition of relationships among many other subjects which would not develop easily in other ways.

Upon the *third* point, or the need for establishing continuity of knowledge in education, it is certain that medicine, recognizing the need for knowledge of this subject by the whole people, will exert a

great power to extend education so as to carry its meaning not alone through teaching of the young, but by continuing the interest and education of mature persons as well.

In development of the science of war a stage has been reached where operations on a national scale necessarily extend beyond the limits of purely military organization, and involve the interests of the whole people. Similarly in medicine, the larger program of the future can be carried out only by extending the meaning and function of medical science into the understanding and life of every individual, so that the operation becomes in large part that of society.

Many nations and civilizations that have failed might have remained had their general educational system been perfected. The time is not distant when we shall have the people as a whole informed regarding basic facts and sources of knowledge covering human health and its advantages.

Concerning the *fourth* requirement, namely, necessary betterment of physical and mental effectiveness of all individuals, this we may consider the special function of medicine above that of any other organized agency or institution in society.

The contribution of medicine toward this end results in enormous increase in effectiveness of the individual, and therefore an enlargement of the total work, both routine and constructive, accomplished by society. This means also saving of lives, increasing the number of hours' work in a given year regardless of age. It means advance of mental as well as physical effectiveness for all tasks upon which individuals are engaged. The net result is to make production greater, to increase the range or scope of living of the individual, to widen his knowledge and better his judgment. It gives a larger measure of what some have recently called "leisure." I would describe it as "opportunity to live," in the sense of opening the way for appreciation of life as we live it, and for growth within the individual life period. It is not merely with advance that individuals and society are concerned. It is the desire to obtain some advantage or joy of living from advance while it is in progress.

Lengthening life of the individual means not merely more years in which to work; it means greatly increased use of cumulative individual experience. The number of persons over fifty years of age to-day, but still working hard with sound bodies, clear minds

and enthusiasm of youth is greatly beyond that of earlier decades. Organized knowledge possessed by the individual is still more effectively handled than organized knowledge controlled by society. Up to the present time the mental mechanism of the individual has been more efficient and works more smoothly than the interplay of parts in society.

As medicine goes forward in development of its constructive policies it will not merely hold back what we consider preventable disease or ill health; it will go far in elimination of much that has been recognized as a part of the normal heritage of ills fastened on humanity. The individual of the future will have relatively large freedom from ills that limit other organisms. The new world which man creates will not only have the advantages of accumulated knowledge—it will have a clearer field for living and for use of knowledge than has yet been known to living beings.

I have no illusions regarding seriousness of dangers brought about by possibility of degeneration of the race through breeding from weakening stock, owing its existence to protection of society. Nor have I doubt concerning the dangers arising from crowding the world with people who have left to them little opportunity for individuality and less for development.

It is clear that certain aspects of natural selection tend to counteract some of the dangers just mentioned and that without a process of rigorous selection we must plan to meet these risks in some other way. I believe that we shall be wise enough to overcome these obstacles and to rid ourselves of the risk of breeding from weak stock. We shall some time come to recognize that deliberately bringing into life people already doomed to a heritage of suffering and of social disadvantage may be a crime comparable to that of taking life away from those already favorably situated.

The *fifth* point, relating to the necessity for contribution toward betterment of economic and political organization, is met by medicine in a larger measure than might be expected. Improved physical and mental health make for higher thought and life, thus laying foundations for bettered organization. Like the delicate adjustment of modern machinery, possibilities of social organization are limited by delicate but real distinctions, such as can be appreciated only through clear minds made possible by sound bodies. Many kinds of finely adjusted social mechanism, which might be operated

by a people relatively free from physical and mental disturbances, would be impossible under conditions where widespread ill health and disease gave a different mental cast to society.

It remains also to be seen how great the influence of medicine may be in direct effect upon economic and political organization as guided by desire for health and fear of disease.

The *sixth* point, relating to dependence of social evolution upon the continuing physical and mental development of the individual, in the sense of his fundamental capacity and power, represents perhaps the most critical item of those upon which the future of society depends. It concerns the possibility of extending such a type of physical evolution as has characterized the organic world through the vast ages over which our known history of biological progress reaches, and has continued itself clearly in the history of mankind.

The problem of human betterment and advance through increasing the physical capacity and power of the individual represents one of the most important opportunities for biological science. The more narrowly limited aspects of this study have been included in the field of eugenics, which rests upon genetics in cooperation with every branch of science which concerns heredity and environment of the individual.

To open the way for a rate of advance in physical being for mankind at least comparable to that which has characterized man in his past history, eugenics must have a program which will include: (1) a full knowledge of the laws which govern heredity, (2) an understanding of any extra-individual or environmental forces which may affect the individual, (3) an understanding of the history or evolution or development of man and of other related organisms, with an interpretation of the processes which are illustrated by this course of development, and (4) an understanding of the ways by which society through its organized effort can properly influence or direct physical development of the individual in such a manner as to strengthen the type.

The study of these problems of biology applied to man represents one of the most interesting groups of investigations needed in the immediate future. It is to be assumed that through knowledge of individual and race history in other types of life we will come to understand in most respects the biological factors involved in human

development. The fundamental principles of genetics will be found inextricably interwoven with basic laws of physics and chemistry. There will be many questions concerning the extent to which certain of the outstanding features in genetics of other organisms actually apply to the case of man. We shall need demonstrations sufficiently clear to bring conviction.

In the problem of development of the individual in the human group we shall meet complications not known in study of other organisms. They will arise on the one hand out of the extreme development of our individuality, and on the other hand out of imperfectly understood influences of the community upon the individual.

There is every reason to believe that with the tremendous advance that natural science has made in understanding of the biological world, and that social science has made in interpretation of our outstanding peculiarities, we shall ultimately come to a place at which man will be able to take advantage for himself both of the laws of nature which have brought his development to the present stage and of the vast social heritage of knowledge which may be used for his future guidance. It seems impossible to believe that the introduction of intelligence into the scheme of evolution could, as some have believed, result in disasters such as are assumed to be inherent in civilization.

I believe Bryant had something of a vision when he wrote, "He who has tamed the elements, shall not live the slave of his own passions." Intelligence should make possible for a man a degree of progress at least comparable to that by which he has come to the present stage.

As, then, we review the elements which seem required if society is to proceed in its advance, it is clear that medicine in the broader sense has important relation to all the factors discussed. In certain fields its contribution is the largest made by any combination of art and science. It is the greatest factor concerned with increasing physical and mental efficiency, saving life, lengthening life and thus increasing productiveness and lifting the quality of judgment. Its direct influence in betterment of the physical stock of mankind and preparing the way for evolution is so clearly essential that without it evolution could hardly proceed.

It is not to be assumed that medicine unaided can prepare the

way for continuing growth or evolution of the human group. In such a work the activity described as medicine will represent concentrated effort of many correlated fields. Chemistry, physics, biology and the anthropological and social sciences would all participate. It may be that the medicine of to-morrow will be so different from what is practiced to-day that in the language of the present it would be more readily described under designation of the sciences from which it will be composed.

The principles which will make possible the physical basis of future mental evolution of the individual and the foundations of a broader and stronger social organization will grow from application of fundamental laws or modes of procedure which biology and other sciences still find elusive and almost incomprehensible. Even the farthest advances of present research fall far short of what we need to know concerning how man may best proceed along the path of evolution. And yet it is part of my thesis that without the work of medicine in preparation of the way by bettered physical condition, improved health, increased mental efficiency, lengthening of life and pushing back of the invading hosts of disease; without embedding of scientific and medical knowledge in the minds of the people by education; without development of a more favorable physical, biological and intellectual environment in response to requirements of the new medicine;—without these contributions of medicine, it could be only through almost miraculous modification of laws guiding nature and man in the past that an intelligent society could expect to advance to greater heights. Medicine will sweep away many of the handicaps that have limited human life in the past and will also help to make more clear the laws that govern our growth.

Medicine of the future will continue refinement of its art and will develop skill comparable to that in the highest coordinated work of human hands, as in their translation of music through playing upon the instrument. Linked with the whole range of organized investigational effort, it will help to extend research to realms as remote, compared with our vision to-day, as the electron was to the scientific world of our great-grandfathers. It will bring to every worker in the field, at the same time, a better appreciation of the importance of the art of medicine and a recognition of the need for understanding as to the real limits of our knowledge.

In my boyhood I read with surpassing interest the tales of knights

who devoted themselves to the not altogether unattractive business of slaying dragons and other undesirable monsters. When I came to the age at which I might enter upon adventure, the dragons had vanished. But I spent some interesting years in helping to bring life into the bones of many ancient monsters buried beneath rocks and mountains that had themselves almost succumbed to ravages of time. The actual dangers of our expeditions from rattlesnakes and bears and ticks carrying Rocky Mountain fever, and coyotes with hydrophobia, were probably equal to those of dragon hunting in olden times, and I enjoyed the sport. The result of our work was, I trust, a small but real contribution to knowledge of movement of life through the ages—and of the meaning of the continuing process of creation.

And now that I have seen these visions—one, through distorted legends handed down from remote centuries, the other, a verifiable story of creation and its meaning—my interest shifts to that growing edge, where life passing through the ages determines in a measure the trend of its own future. My concern is now with utilization of what we have to-day, trusting that, in the light of what we know from the past, it may be turned to advantage for future guidance.

I see in medicine a field of human endeavor, not only essential for well-being and enjoyment of the moment, but carrying unavoidable responsibility for that advance of mankind upon which its happiness will depend. Constructive effort in this subject will serve not only to turn the tide against the deadening influence of disease and ill health, but to exert also in some measure a creative influence. We see the forward movement of life in the remotest beginning of beginnings as we know them. To living, hoping human beings this movement can not seem naturally to terminate in any conceivable end of endings.

Carnegie Institution
of Washington

EVOLUTION OF SOCIETY AS INFLUENCED BY THE ENGINEER

The influences of the engineer on society in general are outlined in the following address, which Doctor Merriam presented before a recent meeting of the A.I.E.E. In addition to pointing out the debt of society to the engineer, Doctor Merriam indicates methods whereby the engineer might be of still greater use in the development of a well-informed and intelligent society. [Editor's note.]

It must be with humility that one concerned with general science undertakes to address a group of acknowledged experts in a field of technical study and operation. Therefore, avoiding the technical phases of the problem, this statement concerns itself with the relation of engineering on the one hand to science, and on the other to human problems illustrated in organization and evolution of society.

It is the purpose of this address to refer specifically to the manner in which engineering opens the road to that kind of a social organization of which we dream, and in which we pride ourselves, whether or not we are correct, on the assumption that our present form of social-governmental organization is a success.

What is said here is predicated upon the idea that there is possible a development of the individual to higher and higher levels of effectiveness and enjoyment or usefulness, in whatever way you may wish to define this situation. These statements also are predicated upon the assumption that society in the broad sense is on a road of development leading to more effective means of organization that in time will produce a better environment in which to enjoy and to accomplish.

As to the relation of science to engineering, the statement can be made that science, which may lay large claim to use of the words creative and constructive, is in general not a creative activity. The scientist is commonly discoverer and philosopher. He may

Essentially full text of address presented at the conclusion of the Edison Medal presentation at the winter convention of the American Institute of Electrical Engineers, January 23–27, 1933. *Electrical Engineering*, vol. 52, no. 3, pp. 171–173, March 1933.

develop, he may reorganize, but in the main he is a discoverer of things which already exist.

On the other hand, the engineer, who is thought of as turning things over and using the results from the work of science, may become a creator and produce that which has not previously existed.

Science is indebted to engineering in that while science may give to the engineering group much that is used for development, the furtherance of science itself is dependent upon what is often referred to as the financial status. One of Huxley's significant remarks was that ultimately everything resolves itself into terms of finance. The scientist does not commonly finance his own investigations.

In looking over the story of mankind one may incline to the view that science, in the natural history sense, was the first form of organized knowledge. There was a classification of snakes that should not be allowed to bite, and of plants that should not be eaten and of those that are good for food. Early in the Paleolithic Period there probably was an organization of knowledge not so very different from that existing today for these materials.

Then came a time in which the problem shifted from keeping out of the range of saber-tooth tigers and snakes, and men occupied themselves more largely with questions concerning how people could get along together. Social organization with government then became the greatest question. Government was perhaps the most important task. It is not yet a complete success, and yet it may be the largest single accomplishment of mankind up to the present day. It is a difficult work but, as badly off as we may be, it is a long way that we have come.

This organization of mankind in government has made possible development of your great engineering programs. Without it engineering could have gone only a short distance. Engineering in turn has placed its resources at the disposal of many kinds of activities, among them the interests of the scientist. Science is now attempting to return to engineering what it receives from this support, made possible in turn by social organization or government in the broader sense.

It is not intended to suggest that science is unimportant. Science is not only significant, but alluring. Adventuring in the field of research is, at the moment, the greatest opportunity that the universe offers. Any one who wishes to penetrate the veils covering

the spiral nebulae, or desires to see inside of the sun or the other side of the moon or the various aspects of theories concerning the expanding universe, has an interesting task.

From one point of view the engineer turns the blocks that the investigator discovers into things that are useful in life, in maintaining life, or extending its enjoyment. From the point of view of a scientist the engineers may come nearer than any other group to being what was just referred to as a creator, in that they can produce things which the universe has never known, and continue to form useful combinations and recombinations.

Not everything done through engineering has its immediate human value in uplift. With all the tremendous contribution made by the radio, the music is not sweeter or better, nor is the enjoyment of music greater than it was before that wonderful invention came into use. Many are being trained to music, but is the training comparable to that received when we tried to construct music or to use it for ourselves?

Also, when we drive through the country in high speed automobiles it is not certain whether we see more, or less, than in the days when we walked. But this statement must not be left with the suggestion that these contributions do not add greatly to enjoyment of living, and to the profit and to the advancement of the individual and of society.

As to society itself and its needs, no attempt is made here to discuss the great social questions at the present moment. It is worth noting, however, that society has passed through many evolutionary stages, and that at the present moment it is probably faced with greater and more difficult problems than at any previous stages in world history. This is due partly to the fact that the world's interests have been tied together by means that developed out of the operations of the engineer. If the world were to go to crash because this situation has developed, would the engineer be in any sense responsible for the difficulties? If, on the other hand, out of these complications there should arise a situation better than any we have faced in the past, would the engineer be said to have assisted in lifting us to a higher level of development in social organization?

It is not planned to catalogue specifically the difficulties in these great social questions. There is, however, reason for stating that present situations are in large measure due to 3 negative principles,

which are: ignorance, bad judgment, and selfishness. The more discussion there is on world problems the clearer it is that the element which is lacking first of all is knowledge of the facts. Judgment is merely the laying out of facts to determine the direction in which they point. The greater the number of facts, the more difficult it is for the average person to form a judgment as to what the situation really means.

When you add the element of self-interest, it becomes extremely difficult with lack of facts, and inadequacy of judgment, to develop a situation in which the great problems of our own country or of the world can be solved. One may refer either to economic questions or to those that concern government.

And now, returning to science, apparently one of the things which the world needs most at the present time is an attitude toward these situations representing a combination of the point of view of the scientist who needs facts, and the engineer who indicates that these facts must have an orderly arrangement with reference to each question considered. If every citizen of this country could approach each of the great questions which we face at the ballot box or elsewhere, with an attitude of mind requiring facts and their orderly arrangement, it would aid greatly in solving our major problems for the immediate future.

As to the question of adjustments in society: at the moment the world apparently has reached a stage in which out of the various needs in life those which have to do with what we sometimes call maintenance, that is, the securing of food and shelter and clothing and such requirements, can be met without use of all the labor in the world. We have produced means of communication, by train, auto, telegraph, telephone, which make it possible for us to keep in touch over the world. But, with all these means of finding where work is and how to reach it, there are millions upon millions of people who have nothing to do.

The central point to be made is this: We have, whether correctly or not, set up a program of organized society with the assumption that the people will have something to say about their government. No one knows what the result will be. It may be that a people governed by a dictator or a monarch, or by a manager, are in a more satisfactory situation than the one we now occupy. But it is probable that through future generations the people will wish to have

something to say about handling the organization which controls them. There can be no doubt that for conduct of such a government we shall require a high level of education, understanding of great national questions, and extraordinarily clear human judgment. Is it possible that shortening of hours of labor is the thing which will open the way for development of an educational program by which the average citizen can form fully adequate judgments regarding the person to be elected as ruler, or concerning questions upon which we wish to express opinion?

Can it be that the situation we meet in the world today is in a manner what is needed to make possible the kind of a government we would like to have? It is doubtful whether democracy can succeed fully without a level of understanding of such problems higher than has yet been attained in any country trying out this system. If so, we must proceed to that kind of an adjustment in which the opportunity offered may be used in some part to make self-government possible.

Perhaps we are coming to the point where we can make the adjustment. Those who are now out of employment may not be the ones to take over the new tasks for education or for improvement. But possibly they can be cared for in the reorganization.

We must continue intensive study of how there can be concentrated in life of the youth the things essential for his beginning education. The young person might spend less time upon this concentrated effort to amass a heap of information before taking up the life he is to lead. Instead of considering his graduation the terminus of education it should be near the beginning. In continuing education of the adult we do not care especially to assimilate masses of facts, but wish to know clear realities in their normal setting. Such a development may be expected in the education of the individual that he will grow in every week of life.

This is then a problem for the scientist, for the educator, for the student of social sciences, and it is especially a problem for the student of government. With all the scientist does to prepare the way for the great things of the engineer he is not in a position to realize in everyday life the whole result of his work. The engineer has a unique opportunity, not just to control, but to build and to guide in the direction under discussion.

Unity of knowledge, diversification, and specialization are im-

portant factors. There must be students of atomic physics, there must be paleontologists, and there must be students of astronomy, but they all represent parts of one great field of knowledge. There must be those who write poetry, and those who preach, and those who teach us the rudiments of art, in order that we attain the most from life as we live it.

We have specialized so far in science that we forget sometimes the relation between work of the biologist studying chromosomes, and that of the physicist working with structure of the atom. We are now beginning to find that great advances in science may come through keeping these types of endeavor so related that the thing needed may be found when required.

The engineer can aid greatly by keeping watch over the scientist, perhaps to see that he keeps on with his task, perhaps to make sure that he receives help when needed. The engineer has a great responsibility in the study of the social problem as related to government. Perhaps he has also a responsibility as a preacher of good doctrine. Whatever has to do with clear thinking and good ideals, may not be separated from life as lived. Possibly we need good preachers among the engineers and good engineers and scientists among the preachers.

A responsibility rests upon the scientist to have some understanding of what the influence of his contribution is upon civilization, upon society. A similar moral responsibility rests upon the engineer to see in what direction his developments are leading us, and the way to formulate such social organization as will make the world we are now building safe for the people in it.

Although we are not headed for destruction, it would be very surprising if progress developed at an absolutely even rate. Sometimes a deviation from what appears the normal path is the element needed to make us inquire what the direction really is.

In conclusion, the contribution of the engineer may be said to be something which paves the way for a social condition or situation opening larger opportunity for the kind of a life we really wish to live.

Perhaps we have tended too much to consider alone the things called comforts, whereas we know perfectly well that it is the pleasures of the mind that are greatest and highest and most important to us. This is true whatever our station in life, or the

profession in which we engage. It has not been intended here to turn attention wholly toward pleasures of the mind, or intellect, or toward art or religion. However, it must be emphasized that these should not be subordinated in any social scheme which we may build.

The influence of the engineer has been all for the good in its guidance toward straight and orderly thinking, and toward artistic expression. When a program is planned according to an engineering scheme, the parts all fit, and something in it is the central element. That is approximately the basis of art, which is, in general, the statement of things in a manner that will attain perfect clearness as to the special point concerned, and also the relation of that element to all others in the picture.

This does not mean that forthwith all engineers should become artists, or students of social science or of government. Evolution of society is important, and with all that the engineer does to make life comfortable, it may sometime be said that the outstanding contribution of engineers has been in the direction of making possible the social organization that we are striving to realize.

INSTITUTES FOR RESEARCH IN THE NATURAL SCIENCES

The problem of this paper relates primarily to a method of organization in research. The purpose and function of investigation are unavoidably involved. When presented before an organization engaged in study of education, it is assumed that the ultimate object of the discussion concerns relation between research institutes and educational agencies.

The development of special modes of organization such as institutes for conduct of investigation in limited fields has come into increasing importance in all phases of scientific work. It is not restricted to any one region in use of knowledge, but has expressed itself widely in universities, to a considerable extent through the departments or bureaus of the government, in some measure through special activities set up by industry, and by establishment of independent units co-operating with other interests.

It is doubtful whether anyone has warrant for defining an "institute" as contrasted with an "institution." Use of these terms indicates that the institute has generally narrower scope. An institution, such as the Smithsonian Institution, may include a wide range of activities. The institute is commonly organized for specific attainment in a limited field. It may look toward intensive study upon one phase of a broad subject, or the accumulation of data in a region which might be expected to furnish results. In some instances, an institute is organized about what might be called a method, or an instrument for gathering or sorting data. In many cases, as the work proceeds, the institute becomes more intensively specialized, or the impetus may diminish through the passing of an individual. Sometimes the need for wider contacts results in the building up of a small institution.

The extent to which institutes in the natural sciences differ from those in the social sciences, will, I assume, be considered more spe-

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cifically in Dr. Mitchell's paper, which is to follow. As I see the problem, the mode of approach, or the attitude of mind represented, is similar in the two. There is difference in the method of application of results, and probably to some extent in relationships to other activities. This may lead to divergent types of organization. There should be no doubt concerning the larger difficulties which introduction of the human element brings in organization and interpretation of material in the field of the social sciences.

"Research," as here interpreted, represents constructive effort expended in the attempt to attain an understanding of human experience and of our environment. Whatever it may have been considered in the past, research is no longer a plaything or a luxury. It is a fundamental requirement in the advance of civilization. We find it opening new universes in space, and time, and human experience—the interior of the earth and the sun, the power of the atom, the intricacies of the living cell, the laws of history, and the processes of human living.

We have come to realize that no condition is more difficult or more deadly than that which arises from the assumption that complete information is already available. This is true whether it relate to material objects or to political situations. Much of the difficulty we encounter today, whether in the study of radium or prohibition or the temperature of Betelgeuse or the farm problem, is due to ignorance. Or, as a problem for the social sciences, I may say that in the case of human questions the trouble may be due to selfishness. The cure for these situations lies largely in new knowledge.

Consideration of the place of research in the natural sciences with reference to further development of civilization indicates that, with our natural resources blocked out and in defined ownership, future material advance will depend upon a continually intensified process of study for development of new means of use, and new ideas to be applied. The contribution of research will also be important in every aspect of living, ranging from maintenance of life to the opening of opportunity for its enjoyment. So important is this growth that our need cannot be met with research merely as a by-product of other activities. It is essential that it have a place of first rank.

The types of special objectives set up in organization of research

institutes spread as widely as the field of knowledge. There are those devoted to broadly inclusive subjects, such as biology, or botany, or chemistry. Others cover narrower areas, like colloid chemistry, or a special phase of biology, as ecological research.

The number of independent institutes in America designed for research in the natural sciences is not large. Types are found in the Franklin Institute, conducting research in the physical sciences, and Wistar Institute, making important contribution to biological science.

In absence of a classification which would be accepted generally, we should probably recognize as institutes certain of the great museums in which a considerable part of the interest and effort is devoted to research in the natural sciences. This would be true of the American Museum of Natural History or of the Field Museum of Chicago. They represent an important educational movement. They also present the results of research in concrete form.

While research agencies are sometimes established on such a basis as to make indefinite commitment to narrowly limited and intensive study of highly specialized fields, there are inherent advantages in flexibility as to topic, mode of procedure, and even as to geographic location.

Organization of projects for a limited period is often important. The concentration made possible by isolation may be advantageous for a time, but rarely for periods to be measured in decades. If the programs can be re-defined frequently, their strength may be increased. We should also realize that the paths along which knowledge progresses may not be defined sharply in advance. Each generation will develop its own point of view.

The research institution which sets itself up solely for a specific type of work will, in most cases, tend to increased intensification. With the passing of decades and the change of personnel, there arise the dangers of narrowing the field and of failure to see the broader connections which were probably in mind at the time the investigations were initiated. Unless resources are available which make possible unlimited development around the special field, there comes frequently a tendency to isolation.

The formal institute should not become a substitute for the project set up for a specific purpose, with expectation that when its special task is completed it will be succeeded by some other

type of activity. We should not be led astray through recognition of the importance of concentrated attention on one aspect of a subject. Such focusing of attention extended indefinitely may result in cutting off the view of other essential aspects of the field.

Discussion of the relation between research institutes and other kinds of activities inevitably involves consideration of fundamental relationships among three great phases of intellectual effort, namely, *production*, *transmission*, and *application* of knowledge. In research we have the effort to increase information and make it available for the maintenance and enjoyment of life. Application of knowledge concerns phases of human activity ranging from subsistence to the enjoyment of living. Education involves all processes by which knowledge is interpreted or is transmitted from one generation to another or from one group to another. Depending upon the conditions governing any situation, these three phases of effort may be widely separated or intimately related.

The relation of any one of the three types of effort to the others is influenced in some measure by length of life of the particular activity concerned. So, in a long-continued educational program, as in a university, contact with research is essential unless it is assumed that the faculty, after having given what it has to contribute, is to be replaced by another faculty. If a research agency is to be long-lived and stand in an independent position, it is desirable that means be developed by which the results of its work can go into use readily and quickly through education and through economic application. Otherwise, through lack of appreciation of ultimate use or purpose, there may be indefiniteness as to meaning of the work. If a great industry lays foundations for continuing growth, it becomes essential for it, on the one hand, to derive some of the elements of its growth from the development of knowledge and, on the other, to utilize the highest type of educational effort in order to make known the value of its operation and its product.

These several major purposes of intellectual effort can never be separated completely. It is important that addition to knowledge, transmission of knowledge, and application of knowledge be considered in relation to each other without regard to which of these types of activity may be the dominating factor at a particular time or place.

By way of illustration of the interrelation of these several activi-

ties, we see in business the great advances of fundamental research in laboratories of leading industries. The fact that such investment is demonstrably practical becomes at once an educational influence so tremendous in its effect upon the public that it ranks among the great factors in carrying over to the people the real significance of scientific work.

The place of the research institute with relation to industry is fairly clear. It may develop within an industry, and serve as a temporary or long-extended aid in development of a special feature, of a special principle, or of a group of scientific problems of particular importance to industry. One need never question that the development under such conditions of practical control will see such readjustments as may be required with changing conditions.

Independent research institutes will stand in close relation to industries. They will make their results available for new advances and will receive many important contributions of fundamental study from industries.

Although it is not my purpose to present an extended discussion of the relation of research to institutions for higher learning, it is desirable to consider certain aspects of the problem as bearing upon specific questions relating to research institutes.

Some of the reasons which I have given on other occasions as indicating the need of research in educational institutions would be: (1) that training in creative or constructive work is, after all, second to nothing as an important element of the teaching program; (2) that research in the university furnishes an indispensable means of keeping the faculty in a position to present the most fundamental and advanced knowledge through its teaching; and (3) that in a group of specialists, such as that covering the whole field of knowledge in a university, the by-products of education through research should make an enormously important contribution.

In discussion of relation of research to education it is also important to note that the world is coming to realization that educational work of the future will cover two great fields which are quite different in their purposes. One concerns transmission of available knowledge to the incoming generation. The other relates to intellectual and spiritual growth or development or enjoyment by the individual after maturity is reached.

In the past it seems to have been taken for granted that educa-

tion ended when the heavy work of life began. Today we accept the opportunities for intellectual development of the adult as a privilege, and also as a responsibility if the individual is to take his part in a government by the people.

The long process of growth or evolution as we see it through the ages has brought into the life of the individual organism in each successive stage a larger volume of experience. Sometimes this change has been accompanied by lengthening of the individual life-period. In general there is a tendency to compress more and more events or stages into the early life of an individual. There is also change in the relative emphasis on structures in early embryonic stages, and a tendency to advance development of features of great importance. So in higher animals, the eye and the brain show a relatively strong accent in their early development.

While the mollusk or even the fish may shift for itself and make its own living at a time when higher animals have yet a long time to wait before being born, the fetus of the higher mammals remains protected for an extended period. Even after birth it remains protected and is the object of special attention. The fawn or the young elephant is guarded by its parents for the considerable period in which it is developing to a stage at which it can furnish its own defense.

In the human group this period of development and protection after birth is extended to one or two decades. To the physical development there is added a further growth involving the absorption of information and formulation of ideas.

If any generation fails to do its part in transmission of organized and interpreted knowledge, the advance of mankind is halted or definitely set back. Interruptions of this nature are not unique. The Maya people of Middle America today, as a virile, intelligent group, examine the work of their ancestors with interest and pride; but, excepting for skill in a few of the fundamentals, they have lost the arts which made possible the majestic development of their ancient culture.

The need for a system of transmitting knowledge to the incoming generation is not merely to carry the data over, but with this must go an interpretation of the essential elements which they represent. This task ranks as one of the most important of all human activities. However significant the development of means for sub-

sistence, or the protection of property, or the invention of new things to become luxuries and then necessities, none of these activities should move this type of education from its high position. I recall that, on my first ascent of a great pyramid in the jungle of Yucatan, the instant thought was that this desolation illustrated what happens if education is interrupted.

The other type of education, touching the privilege of adults for growth and for enjoyment of living, we see growing in importance. In this service widely differing types of agencies have assisted. The press, the theater, the book publisher, the lecture bureau, and a large group of activities have contributed toward the enlightenment, the intellectual stimulus, and the spiritual growth of the adult. In the furtherance of this work the schools will have an important part. It is doubtful whether they can cover the whole field. It is also important to recognize that there are now many agencies in which knowledge is treasured for its own sake.

For the educational institution devoted primarily to training and guidance of the youth, there should be expectation of many institutes developed within the walls. There will also be many institutes standing near the university in much the same relation as that of such institutes to industry.

Consideration of the extent to which institutes for research should be integral parts of universities furnishes a problem which will probably never attain complete solution. To those who hold that the universities are the unquestioned best means for development of hitherto undiscovered data, the institute will be one of the means by which the university will participate in such creative activity. To others the institute will be a workshop, through use of which the professor may support the intellectual life from which the stream of his influence flows. To the man whose work is always a pleasure, the institute may be a kind of intellectual golf course, where he obtains refreshment and strength.

The dangers of the institute within the university are partly those which have to do with the setting aside of education as if it might be relatively unimportant in comparison with the production of knowledge.

In some institutions of higher learning the institute will be a place to which the student will come for contact with the realities of science and perhaps receive his greatest stimulus. Many insti-

tutions, it is hoped, will strengthen their teaching by giving the student larger opportunity for contact with the reality of original materials of the highest type, as also with the influence of men having the fire and enthusiasm of true interest. Opening the way for the student to visualization of reality will often mean the setting up of important constructive work in those fields which offer special opportunity. This is naturally done by way of the research of the faculty. Such formulated activities may sometimes be given the title of institutes. If this type of organization is overdone, it will mean crystallization and devitalizing of the university and defeat of the very purpose for which the scheme is inaugurated. If the program is flexible, it may mean an exceptional opportunity for development of the faculty and unusual possibilities for teaching of the highest type.

The relation of the university to continuing intellectual growth of the adult may in considerable measure be developed through influence of its organized researches, as the progress of science is one of the features of greatest interest to the public.

Attention has already been directed to the fact that the place of the research institute, especially the significance of its position as an independent agency, depends in considerable measure upon the view which we take regarding interrelation of three great phases of intellectual effort represented by production, transmission, and application of knowledge. The opinion has already been expressed that each of these phases of effort has a place of primary value, as also that the three are so closely related that under all circumstances where one is strongly expressed the others should be recognized as involved.

Independent research institutes will always represent one important means for conduct of research projects without limitations. Especially will this be true where the problem is one of immediate urgency. With future increasing demands for production of new knowledge in all phases of life, it is to be expected that the need for new types of research will increase at a relatively rapid rate.

An illustration of an agency meeting a special need is found in the Daniel Guggenheim Fund for Promotion of Aeronautics. It came into existence at a critical time and gave support directly and indirectly to many types of constructive work. The special task completed, it will now disappear. Its influence will extend through

many kinds of temporary and permanent agencies, including universities. All that has been said regarding the dangers of elaborate, long-time investigations in limited fields applies to the institute of this type. Where the problems are broadly conceived, there may be indefinite effective development, provided there is such relation to other agencies as to give opportunity for utilizing all available knowledge for the special tasks which have been set. There can be no doubt regarding the desirability of setting up specific goals in regions where it is clear that areas of new knowledge are attainable. The approach to such regions by use of special apparatus represents an activity of prime importance for the future of mankind.

Where such independent agencies arise for the sole purpose of advancing knowledge, they incur risks of the same order as those which have been discussed in the fields of education and industry. It is desirable that there be understanding of the significance of their contribution both to the narrower and the wider circles of those interested. An institution profits by the stimulus which comes from understanding the effectiveness or lack of effectiveness of its product.

With all that has been suggested, it is important always to bear in mind that there is no specific either for research or for education. There is no special plan representing the only way to success. As in all research, it is essential that in independent institutions there be clear vision of the problem and its relationships and that there be then the most intensive concentrated effort to penetrate at the particular points selected. Established as an aid to medicine, the Rockefeller Institute represents an outstanding example of great achievement in research through intensive attack upon critical questions carried out with support of means derived from the whole of science.

Constructive work in the fields devoted to advancement of knowledge always attains the highest success where conceived in the philosophic sense. Sometimes I shudder when thrown with a person who sees only one thing—the world as seen through a crystal of feldspar or the pattern of a bird's feather—and yet such a person has unusual depth of perspective and clearness of mind with reference to a particular problem. But how about what the feather means to us? What has it signified to the bearers of feathers?

Perhaps the poetry of motion in flight, the narrowing of space, the abbreviation of time? What enjoyment has featherless man failed to realize? The feather alone is nothing. In its wider possibilities it might mean a new world of life and thought.

In the pattern of the new intellectual life of the adult it is to be hoped that the vanishing art of contemplation of things great and beautiful will have an important part—perhaps a larger place than in education of youth. It is certain that in this process of growth the progress of science will have never-ending interest. The independent institute in the natural sciences will overlook one of its greatest opportunities if it fails to recognize the possibility of contributing to indirect education by making clearly intelligible the new material coming from its researches. To industry, to education, and to all who wish to develop in understanding of the world as seen from the periphery of knowledge, such agencies will serve as important sources of stimulus to thinking as well as to building.

THE SIGNIFICANCE OF THE BORDER AREA BETWEEN NATURAL AND SOCIAL SCIENCES

So vast is the field in either natural or human phenomena that one can hardly develop the courage necessary for discussion of both. As one mode of approach, it seems possible to range from either side by limited excursions into the bordering area, constituting in a measure a no man's land where adventuring may be profitable. While other and more direct application of those principles which govern in human and natural science may be more profitable, there is hope that research of this type will help to solve some of the more important questions involved in relationship of the two.

Recent almost unbelievable advances in discovery of processes, or laws, or modes of procedure in nature, are sometimes assumed to indicate the order of progress to be expected in application of corresponding methods to study of human conduct.

Development of knowledge relating to nature has demonstrated that human intelligence can create the means for entering almost totally new universes of thought. At the same time practical application of the information obtained has given us control of new worlds of what might be called engineering opportunity. The transformation of our view of the natural universe through science has proceeded so far that, with reference to many things, we know as real experience today what was once conceived only in the superworld of fancy.

Through these excursions of natural science into the world of matter, space, and time we have opened for inspection such unimagined phases of nature as the structure and power of the atom, the almost unbelievable physical conditions obtaining on the sun

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and stars, something of the nature of the dark continent of the earth's interior, the intricacies of the living cell, and a little regarding the almost infinitely complex problem of life development.

The modern type of research and education as it relates to natural phenomena takes one out to view the face of nature, not as static, but as something which is neither the immediate result of an original act of creation nor yet the end-member of an evolutionary series.

So the geologist looks upon a great scenic feature such as Yosemite Valley, not as the ultimate achievement of geological process, but as the expression of a tremendous and fundamental process at a given moment.

New fields of thinking opened by the penetration of research into nature are sometimes visualized through the medium of a theory, and sometimes by use of an instrument. The microscope shows another world as real and vital as is the larger scheme of things through which we walk about in everyday living. The telescope brings other universes within reach. The geologist and paleontologist, dealing with the shattered relics of great physical and biological features of the past, piece together the remains of formations and of organisms in such way as to present a moving picture of time and change.

The student of the development of the living cell records its slow stages through the medium of the cinematograph. Speeding up these views upon the screen, he sees the result of changes from a relatively long period flashed through in a moment, and recognizes in it phases which would otherwise escape notice.

The vastness of the new regions of thought opened by science, and the dependability of the materials which they furnish, have developed in us a respect for the results which constitute one of the most important factors in present-day life.

Possibly the type of intellectual development of the last century indicates, among other things, the dependence of progress in the study of science upon the development of human imagination. In a measure the visions of the poet have come to be the realities of the investigator. They have also become sufficiently real to form the solid ground of industrial operation and even the basis of dividend paying.

Viewing this subject from another direction, we recognize also

that, with the natural resources of the world blocked out and evaluated, there are calculable, in some measure, the limits of opportunity for civilization of the future. We see that the advance of science shows opportunity of the future to be dependent not alone upon the uses of raw materials as they have heretofore been utilized. The whole problem of the future may be changed by application of new ideas as to means for utilization of the materials.

These situations have brought research in the natural sciences to a place of such significance that it can never again be considered merely a plaything or a luxury—or solely as a by-product from other activities. Recognized as a necessity in the development of means for utilization of the natural world, it is now an element of such importance that its promotion becomes second to no other group of activities.

Another outstanding feature in advance of research in the natural sciences has been the discovery that there are few situations in which the limits of knowledge are clearly terminable. More and more in the study of nature does it appear unsafe to assume that the last item of information has been obtained on any subject. With all the inclination to segregate, and sift, and organize data, there is always the realization that it is unsafe to assume complete knowledge.

What I have said thus far relates to the kingdoms of the non-human in the world about us. A further discovery which science is making lies in the fact that, as between what is called inorganic and that relating to life, the organization of things living represents a field of vastly more complicated relations than that in the non-living. There begins now also to be evidence of appreciation that the contrast between the living and the non-living is only a faint foreshadowing of the type of relation and the difficulties of interpretation which distinguish the human from the purely biological.

The science of human organization is probably among the oldest of efforts for definition of knowledge. Much intensive inquiry had already been expended upon it before science in the field of natural history began to make visible the new worlds upon the conquest of which we have entered.

The great difficulties encountered in human organization today are due generally to one or the other of two simple factors; one is ignorance, or lack of organized knowledge, and the other is selfish-

ness, or the influence of special interests of the individual. It is also true that advance is only too often impeded by the assumption that previous experience has given us the whole of obtainable knowledge.

The enormous difficulties which we encounter in the study of the farm problem, of the tariff, or conservation, or prohibition, would in large measure melt away if complete, clearly organized data could be secured and viewed impartially.

The methods of science have been developed through what are considered as impersonal judgments on the materials of the natural world. In any attempt to apply these modes of research in human problems, one of the safest means of approach is through border subjects in which the scientific method is recognized as applicable, and in which the touch with human problems is relatively impersonal.

In such a field as psychology, the searchlight of inquiry is turned upon problems concerning the nature and composition of elements comprised in the foundations of human conduct. The morphological, physiological, and developmental problems involved in consideration of the physical basis of human living are subject to the types of control used in biological research. The fact that we recognize these as having a bearing upon human conduct almost illustrates the whole of the principle to be established in consideration of the border area between the natural and the social sciences.

Anthropology, or the scientific study of man, might be assumed to cover the whole of the border area, beginning, as it does, with the biological study of man through anatomy and physiology and extending into ethnology, dealing with cultural expression and modes of thought. In this subject we may find practically every human problem represented.

From one point of view anthropology reaches through archaeology into the region of history, and again into the domain of the geologist. Here the controlling principles are those which have been developed through generations of study in the natural sciences, and have even had their dependable application in the harvesting of natural resources. It is also important to note that opinion as to the significance of human history as illustrated in archaeology is not seriously imperiled when the problems considered are sufficiently far removed from present individual, family, national, or racial relationships to permit undistorted vision.

The field of history, as defined specifically, represents one of the most interesting links between a large group of subjects on one side, considered from the point of view of their application to man, and others which have been formulated on the basis of investigation of nature. In classification of knowledge, one is accustomed to hear reference to history and science as co-ordinate, as if different methods or purposes were employed in the two. But more and more we recognize history as expressing through the movement of events another point of view or another dimension in the general scheme of knowledge, in somewhat the sense in which time comes to be related to space in considering the broader problems of the natural universe. This would be true without reference to application of the principle, whether it be with relation to the natural world or to human affairs.

The story of the earth, in which the drama of human experience is being enacted, is for a couple of billion years or so of its extent considered as geology. Here one sees developing the conditions under which we now live, and even the growth of man himself. Of this story we consider perhaps a million years as within the range of human history. The other two billion, minus the million, are geology. Within the human story the aggregate time elements involved in what are commonly called history and prehistory would perhaps be estimated at fifteen or twenty thousand years. The remainder of the million or so is archaeology or geology, and the archaeology is itself read from a book for which the pages and general interpretation are furnished by the geologist and paleontologist. Results of investigation in what have been called the natural sciences furnish a large part of our knowledge of the modes of conduct or operation in development of the world about us. The principles which natural science derives in this study are, of course, only modes of procedure in nature, although we call them laws.

While medicine initiates with the effort to cure human ills, its natural extension into the field of protection of the individual, both against society and against himself, means that this type of organized effort is again an extension of investigation and application, ranging from fundamental natural history sciences into the region of human reactions.

So as we review the groups of subjects which lie in the border area, there is realization of the continuity between the two fields of investigation. The student of natural science may properly count upon the right to extend his studies into much that concerns the human

group. It remains for the investigators on the humanistic side to indicate what it is that distinguishes human institutions or modes of procedure from those characteristic of other aspects of the world.

One hearing this statement would perhaps infer that the point of view of the writer is that of a person attempting to see how far the cold principles of science may be made to carry over into the realm of the human. Presumably that is my function, and the statement relative to the significance of psychology, anthropology, history, etc., is framed with this in mind. I am, however, as much interested in the reverse of this process as in the extension of natural science into the social or humanistic field.

Because impersonal science dealing with descriptive operations has made great progress, we tend to forget that, after all, to human beings the personal reaction to external factors ranks in significance with the character of the outside influences, whatever they may be. The importance of the border area is not to be measured wholly in terms of extension of impersonal science into the humanities. It is valuable also as a means of examining the human factor as it influences science.

Especially hopeful am I that through the border area subjects there may be better evaluation of those peculiar human features that have to do with individuality. Whatever else may be true of mankind, it seems that as intelligence increases and the view of the individual over the universe widens, appreciation of his individuality strengthens. To what extent may this factor, which seems at times to represent human undependability, be evaluated?

Sometimes human variability, like that of a machine, may be attributed to what is called the instrumental error. Human beings at work, even in science, may show systematic, or instrumental, or personal equation errors. Often these must be determined in order to correct the results of work and make them fit what seem to be the facts. Sometimes individuals cannot agree as to what their systematic, or instrumental, or personal errors are. Then, according to which scientific paper you read, the facts may seem to differ. The true result of a really great piece of committee work is often found through elimination of the systematic errors.

Two weeks ago the Carnegie Institution lost, through the effect of a terrific explosion, its ship "Carnegie," equipped for surveys of the ocean. With the destruction of the vessel, it suffered also the

loss of the commander, Captain Ault. In study of the precautions against accident or disaster, there was discovered among the documents a telegram from Captain Ault, under date of middle November, which reads in part as follows: "We grow gray and spend sleepless nights trying to avoid losing equipment not to mention life and limb. At each ocean station the stage is set for any kind of accident and the determining element is human frailty. . . . We have already modified our program doubling the time per station." What is the value of human frailty? In this case it seemed to have been evaluated and eliminated when such determination was possible. At the time of the accident the personnel seemed in perfect adjustment.

Another phase of the human problem especially concerned in study of the border area relates to those tremendous features, the emotions. Whatever they may be, they represent the way the individuals feel about it. Perhaps they can be measured in terms of anatomy, or glands of internal secretion, or physical malformation, or pathology. Perhaps there are other explanations toward which the student of human problems will contribute what the scientist has as yet been unable to discover. I remember standing near a prison in Yucatan. The governor had just addressed the prisoners. As we stood talking over the situation, he said to me, "Dr. Merriam, the question is, shall we punish, educate, or operate?" When determination is made as to what should be done under such circumstances, the conference will probably take place somewhere in the no man's land which represents the overlap of natural and humanistic sciences.

This paper is perhaps expected to raise questions rather than to answer them. I am also safe in assuming that you will consider the statement of any problem to represent at least half the task. The formulation of scientific laws is essentially an attempt to express the conditions as we find them. In reality science does not tell us what nature is but only how it operates. We may not expect to understand human nature fully. We shall come to know more about the principles which govern conduct, and probably learn to see things as they are humanly, as well as in the form of impersonal facts.

It has been said that the line of beauty is curved, because it expresses all of the impinging forces involved. A straight line would be caused only by an explosion or the influence of a single

force. In human affairs it might mean selfishness. It is the line representing truth, sometimes expressed as beauty, that we seek in relation to study of human conduct. It must represent the effect of all forces or influences concerned.

The story of the world as we see it through natural phenomena has brought out a marvelous group of principles, indicating a developmental process so vast that we comprehend it only with difficulty. There are reasons, and much to our advantage, why we should adapt ourselves in some measure to this scheme. In the field of human or social evolution one of the present questions is, shall we permit society to drift, perhaps also to better itself as the ages pass, but by a most expensive process, and without our participation? Or shall we continue with the tremendous task of interpreting human conduct in hope that by the use of such laws or modes of procedure as are discoverable we may accelerate progress and reduce the effort, together with the loss? The desired end will not be attained through any one discipline or any one subject. The borderland to which I have referred may come to be one of the regions giving us the clearest view not only of man's relation to his environment but of his own nature also.

Some of the greatest mistakes in study of human conduct arise from viewing what has been called the spiritual as wholly divorced from the world of nature. Other errors equally bad arise from the assumption that the spiritual is entirely comprised in what science has thus far described in nature. The truth may lie in a view which gives us unity rather than separate worlds of being.

Following my tendency first to state a problem, I have made no concrete applications of the principles discussed. Lest my attitude be considered to represent the wholly detached, or academic, view, perhaps I should say that my life is largely given to these very types of applications—just now in Yucatan, where history in the form of archaeology, supported, on the one hand, by study of the biological and physical environment and, on the other, by anthropology, medicine, economics, sociology, government, and a study of the arts, moves to help in interpreting the story of a great American civilization, and the effect of its contact with another culture that moved across the sea to meet it.

Or if you come to our laboratories you will see biology busy, among other things, with endocrine glands in various relations, from

chemical composition to that influence which may at times cause us to ask, "Shall we punish, educate, or operate?"

In these and other researches we have joy in co-operation with many agencies, expressing many views, physical and human. Among the co-operators we have pleasure in working with the University of Chicago. So when I wish you here all success in the work which this building represents, it is with confidence born of knowledge of your ability and ideals, and the prophecy of great accomplishment in the program to which your effort is dedicated.

THE PLACE OF RESEARCH IN THE PROGRESS OF THE NEXT GENERATION

To one who is historically minded, a forecast of research extending into the next thirty years will naturally frame itself from elements in the history of investigation. Regardless of the effort expended in attempting to make such a statement impersonal, experience makes clear the difficulty of eliminating influence of personal contact where it has really existed. It may be wise to confess that this occasion stimulates the interest of the speaker both impersonally and through recognition of an individual relation.

It happens that the beginnings of my acquaintance with science have intimate touch with the work of persons who had an important part in development of research at the University of Iowa. It is also true that in some of my recent research interests I have had special reason to be grateful for what has been accomplished through activities of the same institution.

As to beginnings of relation to science, my earliest recollection of spoken words presents the picture of a child standing before two enthusiastic students who were reading from a green book the name of a strange creature, Ornithorhynchus paradoxus, the duck bill or platypus of Australia. These formidable words were read to me by T. H. Macbride and Samuel Calvin at my home in Hopkinton, Iowa, in the early seventies. Both men came soon after into service at the University of Iowa. Both contributed no small part to development of science, education, and utilization of the material resources of the State and of the Nation. Between them they covered a wide range of scientific and educational activity. Macbride was professor of natural sciences, then professor of botany, and finally President of the University. Calvin was pro-

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fessor of geology and concerned himself with great questions of conservation of natural resources of the Nation.

The lives of Macbride and Calvin illustrate an important phase in the history of education, science, and research in the State of Iowa. They lived at a time when the interest of the scientist directed itself unconsciously toward examination and interpretation of the multifarious aspects of hitherto unstudied phenomena of the natural world. They worked at a time when, in the struggle for existence, the garnering of natural resources in minerals and the products of the tilled or untilled soil made effective the turning of scientific interest toward the natural history sciences, which had such large value in our learning how to utilize what nature offered.

Although history may neither write its own beginnings, nor give an unbroken picture of moving events, we may assume that the first fairly-organized body of knowledge related to nature. It was not science in the modern sense, but was information required in making a living.

Special knowledge of human conduct as contrasted with natural environment became relatively important when families and clans developed into comprehensive organizations, and social development required better acquaintance with the habits of individuals and of groups. With these changed conditions came the requirement for intensive study of human organization. Perhaps government rather than the natural sciences represents the first carefully organized effort worthy of the term scientific knowledge.

With widening of human contacts, and the epoch of geographical discoveries, there was increase of wealth and multiplication of needs for knowledge of natural environment. These influences stimulated development of the natural history sciences. The fact that this knowledge fed into the stream of practical human use in the husbanding of resources gave added importance, and accelerated the rate of development.

In the past century new phases of science ushered in an epoch of discoveries in nature. The contributions of research have been so voluminous and so fundamental that whatever the trend of our thought may have been we know it to be largely influenced by these additions. This re-statement of our view of the natural world has given a picture of vastly greater scope than that in any previous epoch. Out of the accumulated fruits of investigation have arisen

such great generalizations as those relating to evolution of life through the ages, and the significance of this process in its present practical application, as well as in the tremendous possibilities suggested for the future.

The accumulation of wealth built out of our vast resources, taken with the great accumulation of new knowledge regarding the world about us, offered opportunity for study of aspects of nature that would otherwise have been impossible. So we have seen in the decades leading to the present century an intensive development of the chemical-physical-mechanical sciences giving us marvellous industries and the enormous growth of power characterizing the present moment in history.

Just as the fruits of endeavor in human organization made possible the degree of advance in research necessary for discovery of new worlds in natural science, so now the humanist, equipped with a wealth of new materials and new modes of investigation furnished in part by the natural scientist, seems entering a further and more intensive examination of the bases of human conduct. On an occasion such as this today, when eyes are deliberately turned toward the future, it may be permissible to suggest that the next important stage in advance and application of scientific principles will concern itself more particularly with human conduct and government than with natural science.

As illustrated in the lives of Macbride and Calvin, the history of Iowa shows the last three of the several stages in growth of knowledge to which reference has been made. Development of natural resources and of natural history sciences proceeded together through the closing decades of the nineteenth century. Intensive study of basic laws of nature in many aspects of science characterized the period immediately following. The later years have brought distinction to the University of Iowa in the study of questions growing out of science and reaching into the fundamentals of human conduct. Such are your investigations in psychology and correlated subjects.

The science of human relations and government as it stands today is a type of formulation corresponding in a measure to generalized natural history methods. But just as new conceptions of nature are made possible to us by development of new instruments or new theories, so understanding of human relations will extend

itself through new visions of mechanism and function in that which underlies human thinking.

In natural history the telescope has carried us out to regions of such remoteness that space and its contents reach immeasurably beyond what could otherwise have been conceived as the farthest heavens. The microscope takes us into new worlds which lie about us in an infinity of multitudes. Framed partly by theory and partly by experiment, modern physics reveals a universe of motion and of power in the atom. The vision of time to historian and geologist opens the evolution of things in it to a measure previously undreamed.

So the psychologist in his coöperation with the physiologist, chemist, and physicist penetrates a region in which the physical basis of life as represented in vitamines and endocrines furnishes unbelievable opportunity for guiding and perhaps moulding our future. And yet, with all advances made in the direction of defining the physical as the basis of the psychological and mental, we find in the last analysis that both the physical and the mental seem largely to have eluded us.

The idea of looking forward thirty years as expressed in your program is a bold conception. For purposes of ordinary life the thirty-day period of a household bill, or the four-year period of a presidential election would seem to cover the utmost limit of time for which one could give guarantees. But if one sees the subject from the point of view of the historian, or archaeologist, or palaeontologist, the forecast takes on the aspect of reasonable expectation as it frames itself through extrapolation from the recorded movement of events.

Viewed over the longer stretch of time, it is a fine balance that one discovers in the history of nature and of human events. While poet, philosopher, and scientist may say "nothing endures but mutability," there is yet in the element of change that which stands in sharp contrast to the mere chaotic differing among unrelated states of being.

With our larger vision, the unhurried course of history and of evolution appears an expression of laws which come as near to being inherent qualities as do any other relationships brought out by investigation. We are, moreover, clear as to the fact that we do not deal with mere changes but with connected sequences which may be described as evolutionary.

Science seems to have as one of its functions the development of a set-up which permits prediction. Discovery of a so-called law or mode of procedure means that we are in a position to say that given certain situations particular things will happen. It may be that prophecy or prediction relating to distant times was more fashionable in past periods than at the present moment. In many fields of study we are deeply impressed with the difficulty of prediction, not because we believe science unreliable, but because of the difficulty in bringing together all of the factors involved.

In matters which relate to human kind individualistic tendencies make contrasts and differences predictable elements within certain limits. This seems true both of human individuals and of specific social groups. But prophecy is one of the stock elements in everyday business promotion and in politics. I am not aware that anyone has ever made a study of the relative accuracy of business and of political prognostication, but examination of the results and of the bases of belief would be interesting.

Science begins just now to recognize the need for considering prediction of situations somewhat removed in time, even if of the most general type. Such are those that relate to natural phenomena which influence human living. For example, the extent to which we shall be able to give assurance regarding the habits of the earth as they touch movements known as earthquakes will be of great importance in the future. It may not be essential that there be prediction of the exact time at which an earthquake will occur, or of the grade of violence. It is desirable to know that a particular place may, within certain limits of time, be subject to movements against which a guarantee of complete safety would require a particular type of building.

It may not be possible to say that at a particular spot, at a particular hour, within a half dozen years we shall have rain or sunshine. It will be important to know whether over great regions one may in general expect reasonable precipitation within a period some years distant. The present converging of many interests upon study of the weather with reference to long-range prediction represents one of the most interesting, and perhaps one of the most important, of all applications of science for the benefit of mankind. One finds here the need for almost every item of information that can be obtained from every field of natural science. Such are: the nature of matter as it bears upon the structure and function of

the sun from which we derive heat and light; the anatomy and physiology of remote stars which help us to interpret our own sun; the geography and climatology of our earth, with special reference to the movement of air currents. In another direction we need to know the history of the earth, geological and biological, as an index of past changes of climate. So, from every side, the concentration of interest of physical and biological investigators is centered upon this great question. A solution obtained today would be of enormous value in the business world, and would immediately furnish a sound basis for prophecy in political discussions.

I am sure it is not expected that I give in this discussion a forecast relating to specific problems during the next thirty years. I have already made the suggestion that in the history of science, as we have seen it in the State of Iowa and in our country, we have passed through steps which involve, first, the development of natural history data and, second, penetration of the field of science in such manner as to open practically new worlds of endeavor in physics, chemistry, biology, astronomy, psychology, and other subjects. I have also indicated my belief in the view that the next decades will bring to bear upon the study of man such an application of the results of science as will give us a new view of the human problem, and in many a new opportunity in living.

Following in a measure the line of reasoning up to this point, I have a further vision of science and research as developing in the next decades with the double responsibility of even more intensive specialization than has been characteristic of recent years, and at the same time recognition of the need for further understanding of relations among subjects. When the professor of natural history was replaced by the professor of botany, we were merely on the way to setting up professorships in ecology, taxonomy, physiology, cytology, and other special aspects of biological science. We are now at the point where biochemists and biophysicists give us an important view of some of the more limited fields of study. At the same time we realize that the elements which are most baffling in our researches may lie entirely outside the immediate field of the specialist in biology. It is, for example, desirable to know the influence of cosmic rays derived from remote regions of interstellar space upon ultimate elements of the cell determining inheritance of characters.

We can never return to the stage at which the professor of natural history had available from his own experience all of the data relating to each of his subjects. But the progress of science will give increasing importance to that type of interest which turns attention to the general philosophy of nature, with particular reference to the means through which the furtherance of research in each particular group may be advanced by touch with investigational activities in the whole field of knowledge. So, I predict that in the next thirty years' advance of research in the natural sciences at the University of Iowa, there will be continuing development on the one hand of extreme specialization, and on the other side of a practical and philosophic touch among the many groups concerned.

And returning to one of the elements in my initial statement, I believe that with the passing of years there will be more and more concentration of attention upon the aspects of science which have to do with interpretation of those almost infinitely difficult processes which lie at the foundation of human living, human thinking, and the enjoyment of life as it is lived. The latest steps in scientific advance have shown the infinite complications presented by this program. Nowhere is there a phase of science that is not involved. Nowhere is there a type of research which may not in its ultimate meaning bear upon these questions. But by reason of the complicated nature of the subject there is no field in which there may be larger opportunity for fruitless effort. To assume that everything done in the name of science, and all that is set down as designed for human good is real science, is only to misunderstand the situation. What we require is more intensive research, a more particularly inclusive philosophy, and more careful judgment as to how we may apply it all for the benefit of mankind.

I may not close without having the pleasure of saying that nowhere in the range of scientific activities in the country does there seem to me to have been fuller appreciation of the ideas upon which I have touched than in the work at the University of Iowa. Centering in many departments, and in the studies of many individuals, the spirit which represents the search for truth and utilization of the results for human good has been expressed over and over. The fact that I have known particularly well the great researches of Dr. Seashore, through which he has attempted in coöperation with many others to bring into application the type of effort which I

have considered, does not mean that I lack appreciation of the scientific and educational advances in many other fields. I will end with the statement that if the kind of development represented by your history of the past thirty years is made the basis of an intensified program for the future, you will have a record of which this institution and the country may well be proud.

REALITY IN ADULT EDUCATION

In education of the youth accumulated wisdom of ages must be made available for each generation, or the chain of acquaintance with knowledge is broken, and it becomes necessary to secure again much that has been discovered already. In the attempt to form mental images of many things difficult to present in true reality, the picture of knowledge is often distorted. Inadequacy in this view may be such that when matched against reality in later life the lineaments show little of resemblance.

Whatever may be true of our attempts to give the youth a picture of organized knowledge, there can be no doubt regarding the large part which reality must play in continuing education of the adult. For those who begin in later life the kind of education condensed in the curriculum of youth, the course of learning may resemble that of children, but the number of these is small, and over the years it will tend to diminish in percentage. The overwhelming majority of adults concerned with education will be merely growing in knowledge as contact and experience widen. To these a theory or a law will have interest generally in proportion to the extent to which it is an expression of something real, and seen as having relation to human interests.

Success of an adult education program will be determined in large measure by the degree of approximation to reality in elements utilized. With this type of presentation there must be clearness in logical or philosophical interpretation, and that touch which relates it to personal interest. Coupling of realities with philosophical interpretation may appear to bring radically different elements into the same harness. In actual life this is not true. The thought of even the most unscientifically minded has commonly its guiding principles, however strange they may seem, and the starting point of an idea usually has its basis in something accepted as reality.

Advance in accumulation and use of knowledge has been possible by classification of materials and interpretation through the

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medium of theories. The limited range of our vision has made necessary such means of simplification and organization. This mode of progress has given us so-called abstract knowledge and theories, and numerous kinds of representation in the form of collections, illustrations, and books.

It is reported that at one time in the Middle Ages there arose a spirited discussion over the nature and number of teeth possessed by a horse. Literature was quoted and considerable attention directed to the subject, but without bringing in the living horse. One may inquire how often today we might find teaching of subjects ranging from biology to government largely by reference to literature and negligible use of materials which could be found at the classroom door.

The opening mind of youth may be attracted by mental exercise in collecting, organizing, and reproducing such materials as textbook and classroom furnish. The mind of the adult requires more certain foundations in reality upon which to build. It demands a clear exposition of relationships and definition of perspective. It must have also the evidence of human value even if use be in a field of what may be called the less distinctly practical.

The suggestion that realities are essential in adult education may appear to some as indicating lack of appreciation for condensed description and interpretation through books, pictures, museums, and other forms devised for presenting organized ideas. Habits of education are so firmly fixed that we sometimes fail to recognize the effect of turning our backs upon the things discussed in order to examine descriptions and interpretations. There can be no substitute for observation and personal interpretation as the basis for judgment even regarding comment made by others. Contact with reality only gives increased value to results of observations by those who have had larger opportunity for obtaining information.

Adult education representing maintenance of intellectual and spiritual growth is the best guaranty of continuing interest in life. The soul that ceases to develop is practically dead. Education must include opportunity for the individual to develop not only his knowledge but his judgment. It is not sufficient merely to reflect opinions of others. Whatever the subject may be—economics, religion, science, engineering—it is essential that students be led to the materials under discussion. Without such contact the

picture formed is certain to be inexact. Errors of direct observation may be large, but under any circumstances they are less than those of a second-hand story.

So in all fields of education for the adult, one of the elements of primary importance lies in contact with the thing itself, as foundation for constructive thinking, and as basis of judgment regarding the thought of others.

THE CONSTRUCTIVE ELEMENT IN EDUCATION

GREAT events may come with the suddenness of lightning, but in our historical observation of such movements we find them commonly unhurried and showing evidence of sureness in fulfillment.

We were glad when within a few months of the Armistice in 1918 the shouting and tumult died. I am not certain of our remembering that after the captains and kings had departed the fate of nations depended largely upon the humble and contrite heart. At any rate, we did not realize that the bills, whether in money, in social reorganization, or in revision of ideals were still to be paid. It seemed then that we might go back to life of days before the war without serious influence of the great conflict upon the social order.

After that great struggle each group returned to its special tasks. In many countries the burden was so heavy that only fundamental readjustments made organized society possible. In America we moved through ups and downs of business and politics, apparently carrying little weight compared with the handicaps of many peoples. Watching the throes of rebirth for other nations, we appeared to move along lines comparable to those of pre-war days.

Regardless of specific origin for troubles which have come upon us in these later years, we know that our present situation is, at least, complicated by the fact that the rest of the world has been experiencing difficulties which arose out of the world cataclysm. With determination we have set out to find the immediate remedies, the causes, and the means for building out of the tangled machinery a better and stronger structure of society. We realize now that the evolution of governments and of social organization following the world war is part of a great movement in which some changes appear suddenly. But in general the modifications represent widely interlocking elements, and the rate of shift is in some measure conditioned by the order of magnitude represented.

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Recognizing now, in a manner, the significance of these changes, we have inquired in all directions as to what contributed most to the unbalance which comes so near to bringing down in ruin much that we had learned to consider indestructible evidence of progress. Science, as one of the foundations upon which modern engineering rests, has been asked whether its products may not be responsible for a considerable part of the disturbance. Business is requested to testify as to its real knowledge of what was taking place when destruction impended. Religion is questioned as to its responsibility for maintenance of standards of thought and of vision, such as might have prevented growth of selfishness and neglect of moral law. Education stirs itself also to inquire concerning opportunities and duties in seeking out elements which may have bearing upon conditions that permit such a situation to develop, or can guide us in the future toward paths relatively clear of obstacles.

Examination of the history of education with a view to obtaining light on these questions opens results from centuries of effort to organize and simplify knowledge, and to make available methods through which the most accurate information and highest ideals can be used in advancing education of youth and adult. But what is there in the present educational plan that may be improved so that in the future mankind can avoid these national and world cataclysms? Or what has been omitted from the scheme that could aid in bettering our situation?

It is the purpose of this paper to suggest that, as one feature which should be considered, it is important to continue stress upon that element of education which concerns development of interest in the constructive life. It is believed that added emphasis on the wide group of interests in this field looks in the direction of increased safeguards against disaster, and will enlarge opportunity for joy in life through widening of range for individual and group accomplishment.

Possibility of increasing value in those phases of education which touch the constructive aspects of life as it concerns society will rest in considerable measure upon maintenance of a high position with relation to several factors, among which special mention is made of reality, of unity in nature and in life as it arises out of natural law, and of continuity as derived from history.

Among difficulties which have always faced education is the fact

that the instant any item of information is set down in formal manner it begins to lose reality. How vast a bulk of educational material is of this type, with values tending toward the vanishing point! The necessity for personal experience of what is taught, whether it be geography, discovery of a mathematical principle, or appreciation of art, is so great that one is staggered by the difficulty of overcoming the handicap.

Outstanding among the ways by which one comes really to know new things or ideas are the avenues of experience or discovery, and that influence which we call personal inspiration. Inspiration by contact with the thing itself through our own discovery makes imprint which the mind can not erase. Inspiration coming from other persons, through reflection of greatness which we have not experienced, awakens new vision and helps toward appreciation of reality. Such inspiration may be transmitted by the written word in great literature. In one sense this is the definition of truly great writing. In general it comes by direct personal touch.

Another obstacle which we face arises out of the almost infinite difficulty in obtaining appreciation of relation between that which has to do with the specializing process in knowledge, sometimes known as science, and on the other hand, the generalizing process which technically we call philosophy. Those who have examined the basic significance of the situation realize that science can not exist without a philosophy, and that philosophy is weak without the materials which specialized knowledge contributes. Once there is appreciation of this relation it becomes possible to bring into education that element of unity so important in the modern world. This is true in the sense of geography, or of time, and again of questions which concern broad human interests.

Without an appreciation of why we must accept relation to each other, or unity, of elements in space and time as in astronomy or geology or human history, it is almost hopeless to discuss relationship in human events over the various areas of the wide world at a given moment such as the present. This element of connectedness in events is something which the sciences and history should contribute each from its own point of view. Without it education wastes its vital breath on the torrents of passing years, and history will continue to illustrate the evils of requiring that each generation learn for itself the horrors of war, or the necessity of appreciating

interdependence among peoples on an earth organized as is this world today.

A comparable handicap of modern education relates to the difficulty of attaining real success in any scheme of teaching based upon the idea of a static world. How much education of youth in affairs of life, say in engineering, has concerned itself with methods that were not new even at the time when the teacher learned *his* lessons! By the time the youth so taught reaches his period of greatest activity, at the age of thirty-five to sixty, he may be a quarter to half a century out of date. On assumption that the world is moving, education in such fields should be on the realities of fundamental things which will furnish the basis upon which to build new structures when the time of new needs arrives. Along with this we must have the forward look into a becoming state of society with all its opportunities.

What is taught regarding human affairs must of necessity concern the past, but it must be viewed in the light of a changing present and future. There must be proper stimulus of thought as to what next steps may come, with wholesome and reverent attitude toward the processes which may bring change and new opportunity to build in the individual life which is dawning. Such an attitude can have significance equivalent to the most important equipment that education furnishes.

Granting the fundamental importance of always holding fast that which is good, it is essential also that we recognize responsibility for doing in each generation the things which are expected of it in the light of its peculiar opportunity, and in terms of preparation by antecedent stages. Shall education accept the challenge in the sense of recognizing the essentially fluid nature of governments, business structures, human philosophies, and help to see both that the stream is not dammed, and that its current flows in the right direction? Attempts to dam the stream of movement in civilization are among the most disastrous of possible experiments. Failure to recognize the potentiality of movement is in effect so to act. Education may and should build by use of great examples, but deification of individuals or unquestioning acceptance of old standards may result in such a program of setting up permanent levels or standards that progress will actually be retarded.

So we may look upon the constructive idea applied to a changing

world as an essential element in education. Properly to use such views means broad knowledge, clear perspective or vision, ability to express without overstating, and courage to take the long view.

The particular period in which the spirit of inquiry should begin to make itself felt in education varies according to point of view regarding the function of inquiry. We hear vigorous discussion as to the desirability of postponing development of investigational methods and attitudes until after the Master's degree. Looking at the problem from another angle, I have in mind two children, one on each side of the continent, who on first entering school thought the teachers took too much time in asking questions, and gave the children too little opportunity to find out what they, the children, wished to know.

It is interesting to note that in monkeys intensive inquiry begins early and seems to continue strongly expressed through life.

It is, of course, possible to confuse meanings of inquiry, investigation, research, and constructive activity. The dean of a graduate school, or the professor engaged in guiding advanced students, must hold to rigorous standards if he is to attain success in the kind of training needed to develop the highest type of investigator in his chosen subject. On the other hand, it is possible to set up more or less routine methods of guidance, which produce technically trained men who will do effectively only what might be called mining in unknown regions of knowledge. In such cases there may be only imperfect development of the real urge to inquiry in the philosophic sense, or of the desire to build something into the scheme of things upon which the interests of mankind rest. Construction, investigation, inquiry, may not be synonymous, but the great value inherent in each practically involves the others. In general terms, what we call "teaching students to think" represents the same point of view, although it is possible to stress "teaching to think" without so guiding the actual process as to give it the value of constructive, individual effort.

Some may doubt whether what we call constructive activity is important in the routine of everyday life. It will be questioned whether the attitude of inquiry or of the constructive type has place in life of the average man. That few will be contributors to fundamental knowledge is clear. It is also true that to everyone who accepts a place involving responsibility there is continuous

need of adjustment, and that these requirements for judgment must be based upon knowledge concerning the changing course of affairs both natural and human.

The average man of the future will of necessity live his life largely in a routine determined by customs of the prevailing social order. He will do his inquiring and his constructing mainly in fields which concern application of principles rather than in abstract philosophy. But increasingly he will find his largest measure of satisfaction in the building type of effort originating through his own thinking. As the product of life work of each individual accumulates, the evidence of true individuality will become more clear, until there emerges from the chrysalis stage of mere physical and mental separateness the new-born personality of one who, in discovering an idea, has given to himself the right of individual recognition as an intentional participant in human progress.

Relation between the vision of education expressed through the constructive idea, and plans for educational guidance based upon building of character may be obscure. From my own point of view the two things are intimately if not indissolubly connected. Character expresses the attitude of active and not of passive individuals. No one questions the relatively high place of character representing truth, and giving itself to that type of human relation which builds for better things. There can be no high character without these basic elements of truth and definitely constructive action. What we need is leaders who have wide and penetrating vision, ability to state the truth, and courage to urge advancement of its application.

If education develops with the constructive point of view, looking forward to a changing world in which there is opportunity for every individual to build himself a place, life can have a stimulus such as perhaps no other influence will give.

Even for those who occupy the humblest positions, a practical philosophy which sees something of the sweep of the past, and possibilities of the future in terms of a constructive life would give a new vision. To secure opportunity of this nature has in some measure been the great fight of the ages, which has represented a striving for liberty to build and not merely attempt to gain freedom from restraint.

Such a philosophy as has been discussed, if widely utilized in education, would change materially the complexion of a social condi-

tion like that of the present, with multitudes unemployed, and with students of society and education concentrating on what to do with so-called "leisure time." With such a view as I have taken, "leisure" would not be just time to play. It would be opportunity to realize hopes and ideals; the possibility of attaining true citizenship and of acquaintance with the inspiring influence of real achievement.

LETTER TO WILLIAM H. WELCH REGARDING CLIFFORD BEERS AND THE MENTAL HYGIENE MOVEMENT

February 11, 1933

Dr. William H. Welch,
Welch Medical Library,
1900 E. Monument Street,
Baltimore, Maryland.

My dear Dr. Welch:

I have just been looking over a group of materials relating to the problem of mental hygiene and touching especially the work of Mr. Clifford Beers, founder of this important movement. In watching development of studies in mental hygiene I have been increasingly impressed by the attitude of mind toward problems of this nature represented in the work of Mr. Beers.

In this age, there has been a tendency to look upon science as limited to those things in which advance is by means of rigid formulae or clearly defined relations of cause and effect. While there should be no question concerning desirability of accuracy or of certainty in scientific study, we are quite clear that most of the methods used ultimately reveal inadequacies. In the end I believe we have come to see that the scientific method is characterized in considerable measure by attitude of mind and desire for the truth rather than by complete mathematical-physical solutions of questions.

In the contributions made by Mr. Beers, maintenance of point of view and objective have made possible what we recognize as a continuous advance in study of problems which often make it difficult to secure exact mathematical solutions.

In spite of these difficulties, I believe that the contribution by Mr. Beers in the mental hygiene movement represents one of the truly great advances in our understanding of the human problem.

With my sincere good wishes, believe me

Very truly yours,
(signed) John C. Merriam

Twenty-five Years After: Sidelights on the Mental Hygiene Movement and Its Founder, edited by Wilbur L. Cross, pp. 254–255. New York: American Foundation for Mental Hygiene, October 1934.

FOREWORD TO FIRST AND SECOND ELIHU ROOT LECTURES

In 1921 the Carnegie Institution established a series of lectures for the purpose of presenting to the public clearly stated announcements of results arising from some of its major researches. In this program the lecturers looked upon simple and authoritative statements of great scientific problems as the objective. The types of subjects used are illustrated by the discussions with which the series was opened. The beginning program included lectures by Dr. Arthur L. Day on "The Eruption of Mount Lassen," by Dr. George L. Streeter on "Recent Studies on the Ear as an Organ Determining Equilibrium," and by Dr. Sylvanus G. Morley on "The Chronology of the Ancient Maya." Lectures of this type have been continued with increasing emphasis upon quality of material included and upon artistic presentation.

Shortly after initiation of the first lecture series, it was recognized that a still wider audience should be reached by publication of the lectures both in magazine form and as supplementary publications to be assembled in groups or in volumes. Although not all of the lectures have been published, the material now of record has become a factor of importance in the interpreting of research results contributed by the Institution.

The general lecture series, covering subjects such as those which have been mentioned, was designed to present authoritative, accurate, and easily interpreted results from studies on special problems. With the exception of a few cases, the discussion has not extended into the field of philosophical evaluation.

The increasing tendency in recent years to look upon science as widely important in human affairs has led to consideration of the influence of these activities upon all aspects of life. Some phases of this discussion have extended into controversy, but always our interest in the relation between advance of science and development

Elihu Root Lectures of Carnegie Institution of Washington on the Influence of Science and Research on Current Thought, pp. iii–v, August 1935.

of human values has seemed to deepen. In this review it has been increasingly apparent that the place of scientific work in human affairs will ultimately be established by consolidation of the values of science in the thought of the people as a whole. It is upon such a foundation of recognition and appreciation of science that the future of research will rest.

Consideration of responsibility of the Carnegie Institution with reference to use of the product coming from its investigations has led naturally to examination of means by which the Institution could aid in study of the values of science, without shifting from the field of research to that of other important activities. As one means by which the Institution could help to bring about an understanding of the values of science, it has appeared worth while to plan a group of lectures to be given from time to time on the general subject of the influence of science upon current thought.

It is realized that, while such a series of statements as has been suggested may be made valuable to the public, also there is inevitably an influence upon the thought of the Institution itself with reference to its responsibility for interpretation of scientific truth.

In establishing this lecture series the Trustees wished to recognize especially the influence on the work of the Institution, and upon the thought of the country, exerted by Mr. Elihu Root, who, through the whole history of the Institution, has been a guide and counsellor of unusual vision and of exceptional wisdom. Among those who have known the interest of Mr. Root in the development of science, and in its deeper meaning for life and civilization, there can be no doubt that this influence has been one of the most important factors aiding to guide science along the safest paths.

FOREWORD TO "SCIENCE AND THE PUBLIC MIND"

Reference to the present period as the age of science may suggest any one of a variety of interpretations, according to the question under discussion. It may be interpreted to mean that this is a time when great material wealth or plenty is arising out of the products of science; or it may mean that this is an age in which science is making its most important contribution by opening broader visions of the world with everything in it, and furnishing better, more accurate, and more dependable modes of thought. To those who see the scientific age from the second position, the equipment made available to our minds and the consequent effect upon life are more significant than the wealth produced.

Whatever the point of view taken regarding the essential characteristics of a scientific age, we may not avoid recognizing the dependence of science upon education for development and for continuity of the values obtained. But there may be wide difference between education in its relation to science considered merely as a producer of material wealth, and education in relation to science recognized as an influence upon our modes of thought and manner of life.

Considered as valuable primarily because of its production of wealth and economic opportunity, science and its contribution of plenty might advance from stage to stage under the guidance or control of a relatively small percentage of the people. Education would be essential as the means for transmitting information and for stimulating new ideas leading to increased and widened production. It would also be desirable that the people as a whole become acquainted with the value of science in order to maintain adequate opportunity for advance.

If, on the other hand, the significance of scientific work as developing wider vision, bettered modes of thought, and improved attitudes of mind is considered, then education becomes of sur-

Science and the Public Mind, by Benjamin C. Gruenberg, pp. v–vii. New York: McGraw-Hill Book Company, 1935.

passing importance as the means by which science can be interpreted to the individual and to the masses, and the leaven of its influence be made to permeate the thought and life of the entire population. With this conception of values in science it would not be adequate to have acquaintance with the point of view or the logic of science limited to any small group of leaders in thought. It would be necessary to make provision by which these ideas could become the common property of all individuals. Only through such an extension of the influence of science could we expect to derive the full values which might properly come to the people as a whole.

In this connection it is important to note that whatever the ultimate fate of government by the people, the highest success in a system of that type can be attained only by development of a citizenry thinking continuously and effectively according to a pattern which is fundamental in science, namely, one which involves wide and clear vision, recognition of need for continuous inquiry upon great questions, and the settlement of problems on the basis of facts and logic.

If the argument presented is correct, the relation of education to science will be especially important when one considers the values of what we call science to be found in its influence as a mode of thought or manner of life. Under these conditions it would be necessary to recognize that, while every phase of educational effort is important in relation to science, emphasis should be placed upon avenues through which at least the rudiments of scientific education can become available to everyone. At the same time it is necessary to stress those special means by which such education can be continued into or through the period of major activities in mature life. Tremendous as are the values of education in youth, we know that much of what is done at that time is equivalent to sowing seed which we hope to see develop at a later period if favorable conditions are encountered. In attempting to realize the full values of science it is essential that, in addition to education of the youth, we care for continuing growth by types of adult education that develop at the time when the learning process is adjusted to the most effective relations of life.

Whether they concern science or other subjects, the processes by which this continuing growth of the adult develops will vary from time to time and will, in all probability, never lend themselves

wholly to organization or classification. In science they will include every phase of literature, especially current publications represented by the public press. Much will be accomplished by motion pictures, museums, and the radio, and by discussion of great discoveries, either in pure science or in the operations of well-known industries. Formally organized study groups will also have their part. Critically important is the fact that continuing exercise and growth of the inquiring mind are among the greatest possible safeguards in a government resting upon the ideals and judgment of the people.

The following study on the place of science in relation to adult education prepared by Dr. Gruenberg makes clear the importance of science to the public, and presents an extremely interesting and valuable picture of the types of activities now in existence, or which may be created.

It can, I believe, be predicted that, along with increasing values in a small group of fundamental human interests, such as art and civic righteousness, we may look forward to the growing importance of science presented through adult education as a manner or mode of thought essential in the kind of civilization and the type of government which we desire to see realized.

WASHINGTON, D. C.
April, 1935

THE MOST IMPORTANT METHODS OF PROMOTING RESEARCH

AS SEEN BY RESEARCH FOUNDATIONS AND INSTITUTIONS

RESEARCH by purpose and definition of the term aims at such a wide variety of objectives and takes such different and irregular paths that it is difficult to segregate any small group of methods as clearly the most important. And yet it is desirable to consider some of the means by which creative activity or the advancement of knowledge may be aided.

If one were to select from the many types of effort developed for promoting research, the classification would presumably include methods on the one hand expressed in terms of financial aid and, in another direction, by efforts to stimulate interest in research and develop activities leading to creative work. There would be, further, methods developing out of the interests of widely differing institutions and activities in which the research promoted would be only the means to an end, and the type of promotion used would depend in some measure on the ultimate objective, as in the industries.

The classification of agencies listed in the program of this meeting is itself an indication of the various methods of approach to the problem, different means by which investigational activities may be promoted, different means of interpretation, and different objectives. While learned societies and academies are concerned with many objectives which are the same as those of the university and the research foundation, there may be a considerable difference in the fundamental objective and the purpose for application of the results. It is to be expected that these differences will express themselves in the methods used for promotion of research.

If additions were made to the list I would expect to include reference to so-called professional activities represented by the

Address before an open session of the meeting of the American Philosophical Society, February 20, 1937. *Proceedings of the American Philosophical Society*, vol. 77, no. 4, pp. 605–608, April 1937.

practice of medicine and health protection, together with agriculture and those industries based upon the physical sciences. While the specific objective of all these activities is professional in the sense of service applied for purposes in which compensation is involved, we must recognize the fact that great contributions to knowledge arise through all of these types of work, and that some aspects of research thrive especially well in relation to activities which involve the application principle. The promotion of research under the conditions presented by great industries offers some of the most interesting suggestions and presents many points which may well be considered in discussion of the investigation problem in other fields.

It is, I believe, important to say that contrary to what seems to be a widely-held opinion, the securing and organization of funds does not necessarily constitute the thing of greatest importance in the advancement of research. I am convinced that in many institutions there is not only adequate talent but with this abundant material which might be used, without support of large funds, for constructive study which would be of great benefit to mankind, and would be tremendously important for the individuals concerned.

There are of course many phases of research in which advance of knowledge requires use of extremely valuable materials, the construction of expensive apparatus, or the costly work of gathering data over a wide area or a long period, and therefore special funds must be available if a really important work is to be accomplished; but the problems of this type constitute only a small part of all that needs to be done for the advance, organization, and application of knowledge. I have known a dentist in a small town rather remote from centers of education and research to build up not only an interest but an enthusiasm for a study of nature and for real advances in research by attracting the interest of teachers in the high school, and this extended to the students, the people of the community, and to major institutions of the State.

The phase of the subject of finance which has perhaps been discussed most in recent years relates to what is commonly known as the grant-in-aid, which is also commonly a grant to an individual. Closely involved with the grant-in-aid question and the allotment of funds to an individual, there is of course the seemingly

different point of view concerning selection of an individual because of his interest and ability, or the selection of a problem by reason of its importance.

The stress placed on the idea of selecting the exceptional man by Mr. Carnegie has extended itself in various ways and has been interpreted differently by institutions in their efforts to promote research. It is interesting that there has been less notice of the corresponding stress laid by Mr. Carnegie on the idea of giving support to special projects such as characterized a part of his giving. In the third of the major gifts to the Carnegie Institution by Mr. Carnegie, the special point mentioned was the support of the large project at Mount Wilson Observatory, which was set forth in an interesting form through Mr. Carnegie's statement that he desired to have the work at Mount Wilson pushed as he desired to repay to the old land some part of the debt which we owe by revealing more clearly than ever the new heavens.

The administration of grants-in-aid has been tested out by a great number of experiments and experiences, so that any institution entering upon consideration of this method of promotion of research should now find it comparatively easy to learn the opportunities and at the same time the dangers of this means of advancing investigation. If the assistance is given to a man of exceptional ability in certain directions, it will be recognized that the aid is not assured alone in terms of money, but it must include those elements which have to do with the furtherance of research, including the mechanism by which investigation is conducted, the environment in which the research is carried on, the opportunity for exchange of ideas on the project, and the means for recording and interpreting the results.

If the grant is directed toward the solution of a particular problem, it is essential that attention be given also to the discovery of individuals having such interest in the project that, whatever the importance of the subject its investigation may receive such attention as is necessary if there is to be advance and better organization of knowledge.

Although myself dedicated to service in the field of research, I have consistently maintained the position that real advance of research depends upon having a clear idea as to the general purposes of investigational and creative work. I believe also that real

attainment depends upon maintaining a clear picture of the relations between research and other aspects of science and human interest.

It would be easy to overdo the discussion of purposes of research in terms of broad generalities, perhaps neglecting that intensive study upon which the gathering of facts and the advance of knowledge depends. On the other hand, it would be equally unfortunate if multitudes of investigators in widely separated fields were to delve into the deeper and darker recesses of the universe of things and of thought only to pile up stone and bricks without knowing either the broad structure of the formations from which they are taken, or the ways by which the materials secured can be built into a new type of structure.

Just as a means of promoting research, it would be important to make certain that the scientific and cultural background of the investigation be of such nature that we shall not only place the new facts where they are most effective, but that we shall have vision of the relation between the elements involved as the work proceeds. Research is not solely digging for facts; it is frequently in large measure the imaginative treatment of ideas and materials with a view to discovering relationships which we have not been able to understand.

RESEARCH AND GOVERNMENT

THE PROBLEM OF THE SMITHSONIAN INSTITUTION

Mr. President, Mr. Chief Justice, distinguished guests and members of the Smithsonian Institution. I understand you are here today to consider certain problems which relate to the future. For a discussion of those questions a study of the past is naturally important.

There are very many opportunities which might be considered as within the field of vision of the Smithsonian. I take it to be your purpose, sir, not so much to consider what all these things may be as to consider what the specific objects are toward which this organization should be directed.

The Smithsonian Institution arose at a time when the country was concerned with a struggle to utilize, to harvest, an unparalleled wealth of natural resources. With what seems to me rare vision, the leaders of the Government and the scientific men of this country gave themselves to a consideration of means by which this gift might be made of largest use to all people.

The result was a plan most wisely conceived and wonderfully carried out, a plan by which there was set up under the guardianship of the Government an agency which had its own funds to do fundamental work, with the understanding that it would devote itself first to the development or advancement of knowledge, and then to the interpretation or diffusion of the information which might be obtained, so that it could be of use to the people as a whole.

Those in control of the Smithsonian in its earlier days properly avoided so far as possible tying up the funds in buildings or in formal activities which it might seem necessary to continue to the disadvantage of new work which ought to be initiated.

As the Smithsonian grew there arose out of it the numerous departments or bureaus which have been discussed already in the splendid presentation this morning. Of these some have passed

Remarks in informal discussion at Smithsonian Conference. *Proceedings of the Conference on the Future of the Smithsonian Institution, February 11, 1927*, pp. 60–65, March 1, 1927.

beyond control of the Smithsonian—for example, the Bureau of Fisheries and the Weather Bureau. These agencies, however, are closely related to the Smithsonian so far as the development of their fundamental research program is concerned. They have given themselves, however, to a direct service for the people, therefore they must and do recognize that their first responsibility is to meet requests for information from the people. These departments also recognize that it is a part of their function to carry on research and to disseminate information, and they do it admirably and with increasing effectiveness as the years go by. It would not seem reasonable, however, to set up, for example, a Bureau of Fisheries that would devote itself entirely to fundamental research, and fail to answer questions of immediate economic importance.

There grew up also out of the Smithsonian other agencies, such as the National Museum, which has in the first instance a conservatorial function. The Bureau of Fisheries discovers new specimens and sends them to the National Museum, where they are stored, and where those who have direction of the work of the Museum make scientific study of the specimens and return to the Bureau of Fisheries the information that can be of immediate practical value.

With the passing of the years the Smithsonian carried on extremely important fundamental researches; but more and more, as time passed, its activities and its strength, its administrative organization, were absorbed in direction of the agencies which had grown out of it, or which were turned over to it for administration. In the meantime its income has shrunk in purchasing power and need for the very thing which was in the minds of those who set up the Smithsonian Institution has increased enormously.

We recognize today that we have mapped out our natural resources and know approximately what we have—and we have large supplies. They will last for a long time. But the population increases and the demands increase proportionately. We recognize, also, that now and in the future we must depend on a moderate supply of natural resources and on what we trust will become a very large supply of information as to how best to utilize these resources. So, referring to the need of the increase of fundamental knowledge and the dissemination of that knowledge, which was in the minds of those who developed the Smithsonian, that need has

increased enormously. But the Institution's possibility of doing these things has decreased greatly because the resources of the Smithsonian have, relative to costs of activities, practically diminished in value, and its activities have been absorbed to a considerable extent in administration.

It seems to me that the problem today is one in which, in the first instance, we should consider what the original function of the Smithsonian was and what its opportunities are for the future. I do not say that one should sit down to inquire whether the Smithsonian should be discontinued or whether it has passed the period of its maximum usefulness. But all aspects of every problem should be taken into account if you are to reach a solution. One of the questions to be asked is: As the Smithsonian has developed and become the mother of these children, has it come to the stage in which its original activities will be taken over by other agencies?

The answer it seems to me is that its activities are not finished, that its opportunity continues, that the need of the thing which it was set up to do is an increasing need and will increase during the years; that although we set up other agencies for fundamental research and agencies for service, although we set up a National Museum, which is for conservatorial purposes and also research, yet we must remember that there should be back of all these institutions an agency with the opportunity to use mobile funds in support of the fundamental research needed by the people, but with that freedom which is required if you are to attack really fundamental questions.

By definition, research is the attacking of a problem about which you know relatively little. The Smithsonian in its inner directing or original organization, or its holy of holies, has the problem of attacking the basic or the fundamental principles, upon which knowledge is based. It seems to me that we need to keep in mind the great importance to our Government of all three of these types of effort mentioned: First, the Government department carried on primarily for service, and also developing its fundamental activities in research; second, the conserving group, which embraces the National Museum, having departments responsible for protection and classification of material, and also concerned with research; and, third, this inner group represented by the original Smithsonian. This was the mother of many of these agencies and has con-

tinued its great influence in disseminating knowledge. This inner group should always have the ability to attack the new question when it arises and should therefore have mobile funds so that the new problem can be taken up immediately. Such problems can be considered in connection with the National Museum which the Smithsonian still directs, or in connection with the Bureau of Fisheries, or with any other bureau or department, but always with recognition of the fact that the inner group of the Smithsonian was set up to develop fundamental knowledge, to make it available to the people, and to help develop those agencies which come in immediate contact with the people through the practical application of knowledge in every day affairs.

So, as we look at this Institution and its relations to our Government, it is clearer today than at any past time that an agency of this type, with an opportunity to take up fundamental questions in the service of the people, with a certain mobility in the use of its funds, is desirable regardless of other agencies which may come into existence.

And here let me make it clear that the problem of the Smithsonian is a specific opportunity. It is not the same problem that the institution which I represent has before it. You have a great agency closely related to the departments of the Government, with certain advantages and opportunities that exist for no other organization. It seems to me that the Smithsonian in that inner group should always consider that it has the right to sit down and discuss scientific problems assuming that they have large human significance but without regard to immediate utilities. It is this inner Smithsonian that I believe you should consider, and the continuation and the extension of its activities in the future.

THE OPPORTUNITIES OF THE FEDERAL GOVERNMENT IN RESEARCH

I RECOGNIZE a vast amount of good in development of the research program of the Federal Government. What I have to say is intended as constructive suggestion regarding what seems to me a program of outstanding importance for the country. You have in reality asked me to do two things: first, to consider the relation of education to research, otherwise I would not be speaking before a meeting devoted to education; second, to consider the place of research in the Federal Government.

Relative to the first point, in our attitude toward the use of knowledge we may be thought of as stating our position in three ways: first, with reference to the development of knowledge, which might be called research. You may call it "discovery," or "investigation," or "invention." It is increasingly clear that with the progress of civilization new knowledge must be made available continuously. Nearly all the other kinds of supplies upon which we depend are pretty well blocked out, and we can see how much we have. In the case of knowledge we see no limit. There is a great constructive opportunity in every direction. Research as a profession will be increasingly important in future generations.

The second attitude which I have in mind is that of the person desiring to assist in the transmission of this knowledge to other individuals. Interpretation of the material means practically the same thing. In its various forms this constitutes the field of education.

In the third place, there is the application of the knowledge produced and transmitted. Sometimes I refer to this aspect of activity as engineering; in other words, getting things done with the facts available.

These are three fairly defined fields of activity. Yet I am quite convinced that the occasions are rare when in operation in any one

Address before the annual meeting of the American Council on Education, Washington, May 10, 1930. *Educational Record,* vol. 11, no. 3, pp. 188–195, July 1930; abstract in *Bulletin of the American Association of University Professors,* vol. 16, no. 7, pp. 536–537, November 1930.

of these regions you do not require the support of and close union with the other two methods of operation.

The best illustration of this interrelation that I can give is found outside research. The greatest successes today in the field of engineering industry are those types of effort in which the application of knowledge is closely tied to production and to transmission. The greatest of our industries today give attention even to the most fundamental aspects of research. They feel that their foundations are largely built upon investigation. On the other hand they have, quite properly I think, come to the conclusion that good advertising is just good education of the people as to the value of their product.

So I see also the relation of research and education as one in which you have different primary functions but necessarily a very intimate relation. I do not believe that any educational institution can proceed long without resting very heavily upon research. No educator is safe who is not concerned with study of the fundamentals of knowledge. If he is not doing this he does not know where the limits are, and may some time step over into a field of which he knows little or nothing and talk unwisely regarding it. The safest man is the one who is constantly engaged in verification of the things with which he is concerned.

It is also perfectly clear that education of the youth is a forward-looking process, one looking to a time when things will be different. With the rate at which knowledge changes, all the way from physics to economics, it is important that the student's attention be directed to the foundations of knowledge through use of which new materials are being discovered, or will be discovered, and which will develop in him the proper attitude of mind relative to movement of knowledge for the most active part of his life.

On the other hand, it is nothing less than suicidal for any agency to devote itself primarily to research without keeping in the closest hand-touch with education. In the first place, there is the likelihood that in time objectives will be lost sight of, not in one year or in two or three or in four, but in time. One who is cloistered may forget that there is an outside world, and may forget that service to that outside world is the primary reason for allowing any individual the privilege of engaging in research.

It is also clear that when the products of research are obtained the investigator himself should be in good position to help interpret

the results to the world, not perhaps the best person in the world to do this, but one who should be concerned in such interpretation.

So in my relation to research I feel that the responsibility carries on to a place at which, after the investigation is completed, an attempt should be made to put the results in form such that they may become available to the world. The scientist concerned with the special subject upon which one works receives the results in the technical monograph. The scientist in the next field may receive the results through a magazine or a newspaper statement.

Passing over to the second part of the subject which I am to discuss, namely, the place of research in any governmental organization, I hold to the view that private initiative, or the sense of responsibility of the individual, is the most important and the most fundamental element in development of science, just as is true in development of government. I believe in individual, or private, or group initiative in science. And yet we know that there are certain great questions upon which the interest of the country or the community should be centered in order to use the strength of the whole group. We haven't much doubt about the need of cooperation in war, although it took considerable time for the Allies to decide to work together in the recent Great War. When they did organize as a unit they won the war. Had they not done so they might have lost it.

I am still of the view that democracy is a useful experiment. It is a form of government in which the source of responsibility lies in the people. Democracy must be built upon education and upon the spirit of inquiry, which is only another name for research. It is not possible for a people to vote upon a problem of importance without having in the first place information and in the second place judgment.

I look upon democracy, not only as a "form of government built upon education and inquiry," but as one "seeking judgments rather than decisions." Judgments are built upon information used by the careful laying out of the facts through a process of inquiry. This method corresponds essentially to research. Some other types of government may be built upon decisions. It may not seem to matter at times whether the decision is good or bad so long as something is decided. In democracy we are assumed to be trying to settle questions in the right way, and with the support of the people

as a whole. If this is true, it is important that the people be educated to understand the essential nature of inquiry in its relation to the democratic form of government. Not until this principle is recognized can we have successful democracy.

It is also clear to me that if democracy is to represent the interest of all the people, and if it is to be based upon information and upon judgment, there will be occasions on which the people as a whole should stand behind certain very fundamental types of investigation.

It happens that we have established some forms of investigation backed by the community. Unfortunately I did not hear Secretary Wilbur's paper on "Medicine and Its Relation to Community Education," but I have no doubt that he said what I am saying now: that the community must stand behind the development of a program such as that of medicine if we are to succeed.

We have gone far enough in expressing the wishes of all the people so that at the present time there are highly developed agencies studying problems that relate to defense—we will not say "offense," but war in the sense of defense. We should have a number of great research agencies in the Government—I am not specifying whether it be city, state, or federal—concerned with other basic questions which relate to the interests of the whole community, and especially those which take long time for their solution.

At the moment many consider it dangerous to place in the hands of the Government anything that takes a long time for completion, because there is no telling what bureaucracy or change of personnel may do. I recognize the dangers. I believe, however, that we should be concerned with study of matters such as—I will say the weather—in order not to conflict with any special governmental problem now under discussion. Weather is a reasonably important thing, especially when considered with reference to its prediction over periods of months or years. If I could write out on a piece of paper a formula by which you could predict the state of the weather over the earth for five years ahead continuously, think what would be saved in the way of redistribution of labor, such as our President has supported for so many years We could say, "The crops will be poor this year," or, "The crops will be small," "Move the men here," "Do your extra building this year, and your harvesting of extra crops next year." It might result in a saving so great that it would not take long out of this to pay the national debt.

At the present moment there are various agencies concerned with a study of the weather. It happens that the institution which I represent is carrying on a research which has been under way many years. It is being conducted on the basis of fundamental physical and mathematical investigations. The work is being done in Norway by a very distinguished student with a number of assistants.

Another institution, the Smithsonian, with the aid of a grant from the National Geographic, is studying the problem of variation of solar radiation with the idea that it may be possible in the course of time to tell what to expect in the way of variation of the amount of heat and light coming from the sun over periods of half a dozen or more years.

If these investigations, and others relating to them, should be successful, by a combination of studies of what takes place in our atmosphere through the interpretation of the physicist and the mathematician, and the research on heat and light received from the sun, we might be in a position to predict the weather over a considerable period.

This is an investigation which is fundamentally important to the whole world. It is something which cannot be fully understood in a day, a week, a year, or a decade. It is a thing which concerns you and me, and the nation. There is every reason why all of the parties concerned should interest themselves in its development, whether the problem be solved by this generation or the next.

So in commenting on relation of research to government I am of the opinion that, while investigation should develop mainly through individual and group initiative, there are reasons why the city, the state, and the Federal Government should select objectives that concern the people, and especially very difficult problems requiring long continued study.

There is too little graft, either through wealth or power, on the part of the scientist engaged in research to worry about it. There is a possibility that in change of personnel over the years interest may lag. But I believe that committees of Congress selected impartially, without reference to party, standing behind such investigations might bring about tremendous advances in our knowledge of things concerning the community as a whole.

I have spoken about the weather and also health. I see no reason why I should not also refer to such things as flood control, erosion,

the study of the forests, the tremendously difficult problem of grazing, and then on into questions which relate to education, which relate to those great human problems so tremendously important and yet so difficult even to define. If it could have been made possible to set aside the right group of men a number of years ago to study the problem of temperance without reference to alcohol, the work might have great significance at this particular moment.

The last point that I wish to make concerns the relation of research in the Federal Government to education. In this I come back to the beginning of my subject. There is much discussion as to what should be done with the results flowing from investigations in the various departments of the Federal Government.

In the first place, the task of solving great federal questions is so difficult that real attainment seems always just beyond our reach. The reason we are unsuccessful in the study of so many great national questions is because we do not have the information and the organized knowledge on which to make a judgment. We are always fighting just a little behind the line we wish to attain. So it would seem to me that the departments of the Government should be given every opportunity to take up these great questions without any handicap which might reduce efficiency so far as research is concerned. On the other hand, it is clear that a great responsibility rests upon the departments which are conducting investigations in the Federal Government to make available to the people the results of such researches.

In my own special work, I have been much concerned regarding the best means of handling results of research. But it finally occurred to me that every result from a scientific investigation is what the public press calls spot news. The public is interested in it because it is something that has not been known. Stated in the proper form, it immediately becomes food for the whole people.

Not long ago a distinguished statesman said to me he felt that in the use of materials from the great scientific institutions—the universities, the Government and others—there lay one of the major opportunities for stimulation of the people to a realization of their responsibility in government. He said, "What can you do without a thinking people? And what greater opportunity is there than that of stimulating the people to thought by presenting to them the results of investigation?" In the first place, such service makes

clear the fact that we do not know the limits of knowledge well, and that there is much that ought to be learned. It develops such a frame of mind that when new questions arise they may at least be considered as new. In other words, it develops the important quality of open-mindedness. In the second place, the presentation of these results to the people always makes clear the importance of carefully planned, organized search for knowledge, and of carefully worked out means of attaining judgments rather than decisions.

With reference to how education may be organized in the Federal Government in its relation to research, I would say the less organization the better. Reduce to the simplest possible type the means by which contact is made with other great agencies of the country. Let the government departments concerned with major investigations tend to educate educators and thus keep in contact with other institutions.

So, believing that there are very great questions which need the support of the whole people concentrated in effort of the Federal Government—I favor strongly the development of a research program. This must, of course, be done with extraordinary care.

All of the government departments need support in their desire to put the ablest, the strongest, the most vigorous men in a position to attack the greater questions. The smaller matters can be taken up in many other ways. We should be careful to distinguish between major responsibilities and minor ones when we are concerned with the Federal Government.

Carnegie Institution of Washington

SCIENCE AND GOVERNMENT

What I had thought to say concerns, in the first instance, the relation of science to government. One might claim, with some possibility of proving the case, that this is an age of science. There appears to be no field of human endeavor in which greater progress has been made, at least during the last few decades, than in the broader scope of scientific work.

There are some who look upon the scientist as, in part, to blame for this depression, because he has helped to develop some of the basic ideas which made possible our overproduction of goods, and because he has given us some of the materials out of which were formed certain of the most terrible things of the World War just behind us. One might glory for the greater part of these few minutes in the developments of science, discussing the astounding discoveries in the nature of the atom, and in their application to our interpretation of what we find in the outer realms of space.

At the present moment we are having an extremely interesting time discussing whether the universe is exploding. At our Carnegie Institution Observatory at Mt. Wilson, in California, there seems evidence of a relation between what is called the red shift—that is, the movement of certain lines of the spectrum toward the red region—and the distance of spiral nebulae from us. It looks as if the farther a nebula is away, the faster it is going.

One might turn in the other direction, and refer to the way in which scientists are opening up the sources of energy or power in the atom. In one of our laboratories not far from this building, there has recently been developed an apparatus in which we develop several million volts. This power is transmuted into radiation of the type of radium, or a little more rapid, and these rays are being turned upon the central area, or the nucleus, of the atom, to break it down.

Whether we shall be able easily to transmute atoms or materials

Address before the Interstate Legislative Assembly, Washington, February 4, 1933. *Journal of First Interstate Legislative Assembly*, pp. 21–22, March 1933.

from one substance to another remains to be seen. Whether we shall be able to utilize the energy in the atom comes nearer to being a practical question today than at any time in past history. Some of my friends feel that this is within reach.

In the development of knowledge and human effort we began with a cycle of natural science. Ancient man learned the kinds of plants that he ought not to eat, the kinds of snake that ought not to be allowed to bite him, the kinds of animals that he might eat and those he should avoid. He soon set up a classification of the things about him organized according to what we now call botany, zoology, and geology.

And then, when human groups began to grow larger, there developed that extremely interesting task in which you are engaged, of trying to discover how people can live in close proximity and get on together. This was that difficult work of learning how to organize what we call government, and to develop economic and political principles. Man has been continuously working on the problem since that time. Sometimes we think that the task is not particularly well done. From my point of view as a scientist, seeing the field with a different perspective, I should say that what man has done in the way of developing government so that a world like this can get along at all, is perhaps his greatest single achievement, as much as still remains to be done.

Development of Government

Perhaps even more than we have discovered concerning the chromosomes, and the molecules, and the spiral nebulae, are the things that we have learned about human organization. Still it continues a very great and a very difficult task; one upon which all the knowledge, and all the interest, and all the patience of the world may well be directed with the feeling that it is as profitable an effort as could be carried through.

In the development of government, we have had an interesting experience in the United States. There is here a combination of two kinds of things; the effort to obtain all the personal liberty possible, a perfectly justifiable and desirable thing; and attempt to secure all the strength that may be obtained from united effort of individuals.

I believe in the principle which President Hoover stated in his little book on individualism. I am a strong believer in individuality.

It is my view that the higher the intelligence, the more definite the desire for individuality.

With intelligence the individual sees more of what is about him, and his own self is more sharply separated from what is around him. Any form of government which attempts to submerge the individual is certain to go on the rocks. That can't be done without taking away intelligence.

In the United States one of the sharpest contrasts is between government of the State and that of the Federal organization. The State represents the local interest. The Federal Government represents those powers given by the States to a central group for the benefit of the whole.

You represent States, coming together in an extremely interesting way, to discuss the problems of the States by way of a special organization, rather than by way of the Congress set up by the States. A large part of the influence which develops to control our country does not arise out of political organization. It comes out of our modern town meetings—the Commonwealth Club of San Francisco, the City Club of Chicago, and other nonpartisan, deeply interested and effective organizations which set themselves to work upon problems as problems, and without reference to that partisan relationship which seems to be necessary in our government at present.

So one is interested to see this peculiar kind of a grouping in which representatives of the States come together in an unofficial way in order to study the problems of the State.

My relation to State problems has been mainly through two avenues. The first is a relation to questions which touch the development of scientific organization in the States. Many years were spent in an effort to find out how far a State should go in the organization of its research, how far it should solve its own problems, and how far it should go in asking the central government to aid. It has always been my feeling that the State should do everything for itself that it can do, rather than lean upon the Federal Government.

Natural Resources

A second relation has been through a consideration of natural resources. There has been study of mineral deposits, forests, and

more recently parks. The scientist attempts on the one hand to cure us when we become ill; on the other hand, through influence of the parks, he is trying to keep us in such good health that we will not need a doctor. Especially in these times of depression the out-of-doors is one of the greatest cures for our ills.

So I became interested in the State park as contrasted with the national park, the State forest as contrasted with the national forest, and have come to see the great responsibility resting upon the State to provide for outdoor life and recreation and those curative influences of nature and the out-of-doors which are among the greatest safeguards.

Especially through relation to activities in the State of California, I have been interested in helping to build up protection of those natural features in which the State has provided itself. In a very definite way that State is justifying before the Nation its belief in natural values of the region by purchasing State parks and protecting its forests. It has indicated that it believes what it has said concerning these values.

Through all these discussions, in all the aspects of the problems, even up to the point where they touch taxation, I hope this organization will put responsibility upon the individual, upon the community, upon the city, and upon the State, to work out their own problems, and thus reduce the increasing load of things that we are throwing upon the Federal Government. I believe that States should save the central government from everything that can be cared for at home, and through this build the individual to the highest level of effectiveness, and to the highest level of enjoyment, which in the long run means not only a great State but a great country.

SOME RESPONSIBILITIES OF SCIENCE WITH RELATION TO GOVERNMENT

At this particular moment in history necessity for judgment on emergency questions has brought engineering, science and constructive work in sociology into important relation to government. Whatever views we may hold regarding the significance of scientific contributions in the present situation, this is a time in which questions touching the responsibilities of science to government can be discussed with hope that attention directed to the subject may aid ultimately in advancing understanding of this relation.

Objectives of Science Compared with Those of Government

Although science and the scientific method have become almost the controlling factors in certain great organized activities, as in some aspects of industry, the mode of operation of science has seemed commonly to differ sharply from that of government. Fundamentally, science relates to search for realities and principles and to their interpretation. It is the discoverer and organizer of facts. Science may also be creative, but commonly it is the inventor, engineer and artist who produce that which has not previously existed. Government is a form of organization or administration designed to make it possible for human beings to work together with mutual advantage. Its operations must be based upon realities or the truth, but their basic objective is the furnishing of means for bringing about relations among people which, according to current views of democracy, will give the maximum contribution of power or strength or wisdom for the whole group, and at the same time the highest degree of individual liberty consistent with such organization.

Though fully effective government must be organized on the basis of facts and of those principles which can be demonstrated to repre-

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sent the best interests of the people, often control is by brute force, by influence of money, or by many other kinds of power. Or government may be through control by types of propaganda representing ideas imposed upon thought of the people. Some of these suggestions may represent the truth, and others may be far from correct. Whether or no we recognize such government as legitimate, it may nevertheless be a foundation upon which much of human organization rests.

Again, it is necessary to realize that a government by the people will be what the people desire to have it, regardless of our specific views as to what it ought to be. Ability of leadership to accept such situations, and still in some measure furnish guidance, may be an important element, and yet be difficult to measure according to standards of scientific evaluation.

The problem of human organization or government must then be looked upon as representing a group of objectives quite different from those commonly visualized by the scientist. But in spite of this difference, it is important to emphasize the idea that ultimately in conduct of its affairs government rests upon elements which may be subject to investigation through the modes of approach used by science in search for the truth. Seen in this light, the responsibility of science may appear very large with reference to problems which relate to government.

As the term science is commonly understood, there has been much difference of opinion concerning the extent to which we may reach from this field into the region of human interests represented in government. From my own point of view, while science will deal in large part with elements which concern the natural world, it must be looked upon as representing an attitude of mind rather than the study of particular types of material. What has been called the natural history of man, illustrated in anthropology and psychology, extends into a great variety of peculiarly human problems. It expresses itself in another way in the type of historical research represented by archeology, paleontology, and geology, presenting the evolution of man and his cultures. So far, then, as one can follow the study of human kind by use of methods which determine realities, and the relations between such real materials or states, we may look upon science as reaching into the investigation of human relations, even touching the field of government.

So, in the American Association for the Advancement of Science we have divisions of the organization concerned with human questions so intimately that we recognize overlap of the natural and social sciences spreading into the field of economics, and even including problems which would be called governmental.

Relation of Advance in Science to Evolution in Social and Governmental Activities

In viewing the relation of science to government from another angle, it is interesting to consider the achievements and progress in these two fields. The average estimates on rate of advance in knowledge have been assumed to indicate that science is the outstanding human activity of this time. That a wide road has been broken through boundaries which once marked the limits of knowledge regarding the natural world is clearly true. Extension of scientific thought taking us out in space to remote nebulae, into the minutiae of matter in the atom, and back in time to periods earlier than the date of man's creation, makes it impossible to avoid the view that science has entered wholly new worlds.

But great as are the achievements of science, we must realize that over long ages mankind has been moving forward in the work of constructing a stupendous and complicated organization which makes it possible for human beings to live and work together. Through this striving there has been developed in government a means for adapting individuals to each other which is perhaps the outstanding accomplishment of the human race. In spite of views which we as scientists possibly hold, government, with all its weaknesses, may represent the most important contribution of human experience up to the present time. But since government is not yet shown to be wholly scientific, and science is not yet fully adapted to government, the problem of the moment concerns means by which continuing development in forms of organization and administration essential for well-being of the community may be given the support which should come from constructive efforts through science.

In consideration of this particular question it is desirable to ask whether the contributions of science toward solution of social, economic and governmental questions may aid in opening the way for new types of advance in governmental organization. May we

expect further movement in the fields of human research corresponding to that widening of vision and deepening of thought which were made possible in the natural sciences through construction of the microscope, telescope and theories like those expressed in the developmental or evolutionary view of life?

The almost infinite complexity of human affairs as compared with situations in most problems of natural science indicates that a restatement or reorganization or redevelopment of social, economic and governmental science comparable to what has occurred in natural science will probably take place only through effort vastly greater than that which made modern scientific advance possible.

Further development of government will show, among other critical features, that we need to consider human attitudes as they are encountered, though we may not justify them on the basis of scientific judgment. In examination of the factors involved in many great human problems there must be recognition of states of being and points of view for what they are, even if the conditions do not seem to fit completely into categories set up on the basis of facts and logic as we have catalogued and interpreted them in natural science. The emotional features of human beings and their individual independence increase the difficulty greatly. And yet it seems within the bounds of possibility that further great advances in evolution of government may occur, corresponding to those in our knowledge of the natural world around us. It is a part of the responsibility of science to consider the extent to which cooperation with investigators devoted to problems of government may facilitate such advance.

Education in Science as Related to Development of Initiative and to Quality of Judgment on Fundamental Problems of Government

One of the most critical questions touching the value of science in its relation to public affairs concerns the possible influence of the scientific attitude upon development of initiative and upon the quality of judgments required in solution of many new types of problems fundamental in government.

Future students of our political organization may be able to determine the extent to which ability to obtain and to maintain political power is correlated with capacity for solving great questions of the

commonwealth. The natural development of government will presumably bring us increasingly close correlation between these two kinds of ability. The modification may come through bettered education of the people. Over the centuries the ultimate effectiveness of any government of the type which we support depends upon the capacity, the interest in critical questions and the point of view of the citizens. Though great leaders arise, in general the judgment of an educated citizenry will determine the nature of authority of government and the levels which it may reach.

While attempting to develop a governmental organization giving advantages of strength for the whole group, we endeavor to maintain freedom of thought and initiative. Whatever else is controlled, our religious views, our ideals and the opportunities for constructive work must be free from domination by central authority.

In development of the highest type of citizenship, inquiry and initiative are essential. This attitude represents precisely the point of view taken by science and research, which must rest upon and grow out of inquiry and initiative. Through the field of education, scientific subjects should have large ultimate influence upon the manner of thought of the people, and therefore upon government. Development of the attitude of mind which they illustrate is essential in maintenance of a democracy. If democracy represents the people, its roots must be in the people, and this involves ideas and attitudes as well as other things assumed to be more clearly defined.

As science, research and constructive thinking have developed in America, much of great significance has arisen within departments set up by the government. It is to be hoped that governmental policies will lean toward even greater extension of aid both to fundamental research and to its application. And yet, we must expect in the future, as in the past, that the sources of scientific initiative, like the sources of governmental authority, will arise from the people under a great variety of conditions and in institutions and localities as widely spread as are the boundaries of the country.

Non-governmental agencies representing a broad range of public interests, such as the Commonwealth Club, of San Francisco, are critically important sources of initiation and development of thought. Especially is this true of social and governmental questions. The research activities in organizations of this and of very

many other types have a fundamental and far-reaching influence on the development of inquiry and initiative, and ultimately upon public judgment.

Fundamental Science in Governmental Programs

In study of great problems with which the government may concern itself, as in development of the present soil erosion program, or of study on land use, or in many other comparable questions, it is necessary to distinguish those elements which have to do with basic scientific factors from others which have been defined in terms of social, business or administrative values. Continuing development in our understanding of these major scientific questions will depend upon increasing knowledge of underlying principles. It is the responsibility of science to give its clearest thought and strongest effort to definition of these principles and to their intensive study.

It is necessary also to appreciate the fact that in contrast to what have been recognized as scientific elements, no program of this nature can be carried forward unless there is clear recognition of the interests and desires or aspirations of the people concerned. For example, adequate land use is dependent upon what the people of the country or the world desire to do. If, as illustration, it is believed that primitive natural beauty has an important place in development of the ideals and interests of mankind, then it is essential that there be clear definition of the purposes involved and that provision be made for protection and use of such features or areas. If it is believed that mankind should outgrow the influence of that natural beauty which existed in the world as it was made, and develop into what might be considered a higher state of living, then primitive nature should be disregarded.

In study of great problems clearly of national interest, such as weather prediction, basic scientific research will continue to be one of the most important contributing elements. The information may be related to extent of variation in radiation from the sun, or the nature of physical phenomena involved in atmospheric movements. Or the necessary scientific data may concern the form of the earth and the influence of land features upon movements of air and water. There is no case which seems to indicate greater need for correlation and integration of results derived from many sources than in that touching acquaintance with the climate and weather,

and prediction of their moods or changes. For investigation of such questions it is important that science give its fullest aid wherever and whenever assistance is possible. The breadth of the foundation from which science and its application must build is indicated in the necessity for international cooperation in study of climate and weather.

It is well known that in no application of science is the need greater for aid of government to the people and for contribution of science to meet needs of government than in questions touching development of agriculture. The fact that cultivation of plants in a multitude of ways will always be possible as individual projects on a small scale means that much-needed application of constructive effort through science will in considerable measure be conducted by the whole people or the government. But the vast difficulties of research in the fundamentals of such subjects as genetics, photosynthesis, the chemistry and physics of plant biology and the influence of environment upon variation are so great that the contribution of all available research must be given to aid governmental agencies if the largest measure of success is to be attained.

Science and the Problem of Planning

The train of events reaching from the world war into the recent depression having given exceptional stimulus to study of national and world problems, one product of this discussion has been the exceptional development of planning. On one hand are proposals which would hold society to rigorously defined programs laid out by government. In other directions are modes of organization intended to increase liberty of the individual. Whatever the ultimate result, we are now considering the responsibilities of each generation for taking stock of assets and opportunities, and for such a forward look as is of advantage now and for later years. While it is not to be expected that a completely adequate program will be developed immediately, it is of great significance that we begin to recognize clearly that there is a future and that we have relation to it.

It is possible that some of the most important relations of science to government will touch this field of planning. The great study on "Recent Social Trends," carried out by a committee under the chairmanship of Herbert Hoover, contributed in an exceptional way to fundamental materials required in consideration of planning pro-

grams. It is important that information in the field of science be examined with reference to its possible value in study of major national or governmental projects.

A wide view over the materials of science and history indicates, I believe, that until we know the past, its processes and experience, we shall not be equipped completely for satisfactory planning. The scientific study of history, with its stages of archeology, extending into early records of the earth and of life, is essential in such a program. Only a people acquainted with the basic meaning of history in the sense of the longer reaches of time, as well as with broad international relations, can make adequate judgments on overshadowing world problems such as face us at the moment. Ingrowing nationalism, which tends to neglect the world, both geographically and historically, is accentuated by lack of perspective.

If available methods of education in history do not give us the needed illumination, I shall hope to see more works like H. G. Wells' book of several decades ago on "The Discovery of the Future," based upon results from scientific and historical study of the past. Perhaps one should say that to-day the prophet is not without honor save when he stays so much in his own country, or thinks so much of his own region and day in history, that he does not know the world either in space or in time. So the relation of science to government may be critically important in that group of functions which concern the forward look as based upon the experience of history.

As bearing upon future relations of science to government in the study of planning activities, one may not avoid calling attention to the probability that the materials of science will continue to increase at a rate not greatly different from that of recent decades. Especially in planning programs is it important that new material be taken into consideration. It is therefore necessary to have increasingly close touch between scientific research groups and agencies of the government concerned with activities of the forward-looking or planning type.

Conclusions

There is no responsibility of science relating to the future of the country greater than that which concerns development of such an interest in scientific truth and realities on the part of the people as is

needed to guarantee that the highest values in life ultimately prevail. In this relation the specific responsibility of scientific agencies is very large. This will be met:

First, by increasing emphasis upon the most fundamental types of investigation for the advancement of knowledge in every department.

Second, by bettered means for interpretation of science and for education of the people as a whole regarding the status of scientific knowledge. In part this work must be done by scientists themselves.

Third, by improved means for securing application of results from science, and at the same time better control of materials secured but not at once applied.

One of the ultimate cautions to be expressed in considering the rôle of science concerns recognition of the fact that, although essentially science represents certain aspects of truth and reality, there are other phases of human interest, as in art and our fundamental philosophical and religious beliefs, which may be looked upon as having meaning at least comparable in importance to science. While it is necessary for us to define the realities and the truths represented by science, the elements sometimes called human values are realized largely through appreciation of what is involved by use of other coordinate or correlated modes of thought, such as those that have been mentioned. In considering their relations to government it may become a responsibility of scientists to join those concerned with study of these other aspects of thought if the ultimate human meaning of scientific truth is to be made clear.

The significance of science as an essential feature in the life of the nation will be kept in balance by the people according as experience and education establish standards of value in which science and its truths take their place along with other critical human necessities. The scientist will not lose sight of the idea that his subject is only one of several requisite groups of things. And while it is necessary to remember that he will be held responsible if he fails to set forth the worth of his discoveries, it is also important to realize that science will be held responsible if over-emphasis is given to isolated groups of facts without reference to their real human significance. It is the responsibility of science to state the truth cautiously, and with care that harm be not done. The manner in which a thing

is presented sometimes goes far to nullify the value of what may have great intrinsic importance.

Science should help to develop a clear appreciation of the needs of government, and so to organize and interpret its findings as to aid in solution of all possible problems. This means effort to learn what the application needs are, in order to be aware of the places to which new materials should go for the highest types of use.

The scientist should not necessarily expect to administer the results of his own work, and yet the relation to administration is extremely important. He can not avoid considering the broader implications of his contribution, any more than the student of human questions can avoid knowing something of the meaning of scientific problems if the results of science are to be fitted into the economic or governmental plan.

With these known factors concerning the value and opportunity of science appreciated by an intelligent, educated people, thinking continuously, constructively and unselfishly upon needs of the government, a great contribution would be made in guiding the nation along a safe course.

Carnegie Institution of Washington

THE RELATION OF SCIENCE TO TECHNOLOGICAL TRENDS

JUSTIFICATION of a planning program in technology, as in other subjects, may arise from recognition of continuing change either as indicated in past records or in the conditions of any given time. If accurate prediction of future situations were possible, it would be important to plan the adjustment of flexible elements in all activities to conditions of the future. If precise forecasting is not feasible, forward-looking plans would still be desirable, as furnishing means for quick adaptation in order either to avoid cataclysmic changes or to carry out constructive programs. The extent to which effective planning is possible will depend upon the accuracy of our knowledge concerning both individual features and the laws expressed in changes known to have taken place.

Modification in what we call the result or contribution of technology as illustrated in industry sometimes occurs so quickly that it produces disturbing social influences. If such shifts could be foreseen, many difficulties would be avoided. If they cannot be predicted, it may still be possible to understand the circumstances sufficiently to avoid unfortunate effects if precautionary measures are taken.

The relation of science to technology has become increasingly important as the products of research come to have a more significant place in industry. In development of this relation connecting science and technology and industry, the responsibility of science to the contribution of technology is evident. But commonly the relation of science to industry and technology is only in part direct; generally it is the application of inventive genius in utilization of results coming from research that brings about the rapidly developing series of changes in engineering and industry.

In report of the Subcommittee on Technology, National Resources Committee, June 1937, *Technological Trends and National Policy, Including the Social Implications of New Inventions*, part two, "Science and Technology," sec. I, pp. 91–92. Washington: Government Printing Office, 1937.

The importance of the relation of science to technology and to industry depends in considerable part upon the expectation of changes in science which may affect technology and influence industry or even the general trend of thought. If we were known to be dealing with a static world in which our knowledge regarding all available materials and of man was approximately complete, it would be possible to formulate plans which, with slight variation, might operate almost indefinitely. It is, however, clear that by whatever means we view the history of science and research we are seen to be dealing with almost continuously changing conditions to which adjustment must be made. Activities coming out of the growth of science have given us means for new development of transportation, geographic discovery, communication, and a multitude of other things, perhaps culminating in the automobile and the radio of the present day. A relatively large percentage of these recent advances has arisen from the contribution of science carried to application by engineering. A critical question in discussion of this subject concerns the expectation of a continuing supply of new knowledge from science which may lead to technology and industry.

We may perhaps set down as one of the most important contributions from modern science and research the suggestion that we are probably very far from having a complete knowledge of anything in the world of physical, biological, or human values. In the universe of things physical alone, very great advances have been made within the last generation in our knowledge of materials, forces, and conditions encountered on all sides in everyday life. In biology the degree of complication is still greater, and investigators generally hold that we are just beginning to understand fundamental life conditions and processes.

To those acquainted with the development of science there is little difficulty in accepting the suggestion that our knowledge of nature and man will increase greatly with the coming centuries. It is also to be expected that human constructive activity will bring about the creation of conditions and relationships which have not previously existed. If this suggestion be accepted, development of any planning program of national scope must take into consideration the significance of these new factors in bringing about readjustment. While it is not possible to predict the direction which such changes will take, or the specific fields in which discoveries, inventions, or

new creative activities may express themselves, it would be unfortunate if these possibilities were neglected in a general planning program.

It is essential also that a planning program give attention to study of the actual applications being made of values derived from research in its various forms. Organization of means by which results of science already available or arising through new discoveries could come into human use might mean an enormous contribution to betterment of conditions for life.

The law of survival of the fittest would ultimately care for new materials and new ideas. But our knowledge of evolutionary processes over the ages indicates clearly that intelligent grouping or cooperation or guidance, without the necessity of absolute restraint, may bring about relatively favorable conditions, and in a shorter time than is possible through influence of the law of survival of the fittest or the fight for existence. It is a part of the responsibility of an intelligent people to consider values which it creates and their relation to other values. It is doubtful whether long range planning activity can perform a more important service than that which may be contributed through study of possible situations in this field.

Further study of all programs relating to protection given by patents may aid in discussion of this question. In accepting responsibility for adjustment to advances through discovery and invention, it is possible to plan a program of patenting which would consider public interest to a larger extent in directions where such interest needs protection.

The means by which adequate balance can be established among the interests and contributions of science leading into technology and industry and the elements arising out of studies on social, economic, and governmental questions cannot be determined through the thought of a moment only. They represent some of the most difficult among all human problems. They involve on one hand the possibility of high development of specialized knowledge and, on the other, the organization of society for mutual benefit. The spread between the highest expression of these types of interests is wide. But there is an intermediate position which must be found in order to secure the benefits of all.

From a number of directions we have the suggestion that for guidance in development of new ideas, and for the protection of

society, it is desirable to set up types of organization which may bring together scientists, engineers, and forward-looking students of social and economic problems with a view to keeping close watch upon related problems in these several fields. The finding of something like common viewpoints for investigators in different subjects may be difficult, but it will have increasing importance. Such an activity might be established in the hope of fitting new ideas and new techniques to advancing industries and to new phases of social and economic endeavor. If developed guardedly, such a forward-looking program presumably would not hinder the advance of civilization, and might be expected to aid in adjustment of human groups to some of the changes which inevitably take place.

It is important to note that a responsibility for keeping in view the possibility of social influences arising from use of scientific techniques rests in part upon the scientist. Assuming that there will be an uneven movement in the economic-social stream, there is value in having those best acquainted with the nature of new materials and new activities keep in mind the fact that they, as the source of such influences, should have some acquaintance with ultimate application of their products. At the same time it must be realized that unwise use may be due to factors of social significance with which the student of social problems should plan to keep close acquaintance.

In following the implications of these questions it is, among other things, important to examine the idea that scientific methods may function as techniques, which in various ways influence modes of thought and even concern aspects of judgment. If science exerts this influence, it is essential that its contribution be guarded with the greatest care as to its use in education and also watched by the ablest students as to the manner in which it may affect or guide thought. As one possible influence of science upon thought, we may assume that if the minds of all citizens could be so informed and trained that as a rule there would be insistence upon having and using the elements of fact and reality, which are the basis of science and research, there would be guaranteed a relatively safer situation with reference to the handling of all human problems than has commonly obtained.

CARNEGIE INSTITUTION ADDRESSES AND EXTRACTS FROM REPORTS

FOREWORD TO PAMPHLET DESCRIBING 1932 EXHIBITION, CARNEGIE INSTITUTION OF WASHINGTON

While the exhibits described in the following pages all represent progress in research, they are also planned to define problems and to interpret them in terms of relation to other subjects. The principle underlying organization of the exhibition has special meaning at this time of wide discussion on the human significance of research.

It has been suggested that advance in science and engineering so far exceeds progress in application of moral and ethical principles that there is inadequate adjustment of conduct to opportunity. If this be true, it is important to know where the responsibility lies. If enthusiasm of science has contributed disturbing factors, does the obligation for determining use of product and influence of changes rest upon economists, or on students of social and governmental problems, or on experts in morals and ethics? Or should the scientist have some share in accountability for interpreting the significance of his own contribution?

True science can not develop without a philosophy. Only by interlocking with other fields can it understand the problems peculiarly its own. In recognizing this interdependence of subjects it is natural to accept a share of responsibility for seeing and interpreting the conditions developing out of research.

Science is the great contributor toward appreciation of an orderly, dependable universe. As result of its efforts chemistry replaces alchemy, medicine becomes a healing, understanding art, and superstition fades. Standing continually face to face with the great unknown, the investigator is humble and reverent. His attitude guarantees that, at least by clearer picturing of relations involved in the progress of science, contribution will be made toward avoidance of ills that rise along the way.

Exhibition Representing Results of Research Activities of the Carnegie Institution of Washington, p. 6, December 9, 1932.

THE TWENTY-FIFTH ANNIVERSARY OF INITIATION OF RESEARCH IN THE CARNEGIE INSTITUTION OF WASHINGTON

The founding of the Carnegie Institution of Washington was of peculiar significance as an influence turning attention toward advancement of knowledge, as contrasted with its restatement or transmission. The establishing of an agency for this specific purpose did not indicate that such activities were considered either more or less important than educational work. It presented rather a coordinate or supplementary program, which would naturally gear itself closely to that of institutions designed initially for the work of education, or for other special applications of knowledge.

A group of the principal departments originated in 1904. Among them were Terrestrial Magnetism, Mount Wilson Observatory and Experimental Evolution. The last of these formed the basis for development of the present department of genetics. In the history of the institution many types of organization have been used, and there have been numerous changes in statement of program. So the contribution of Mrs. Harriman, through gift of the Eugenics Record Office with its generous endowment, led in 1921 to union of eugenics and experimental evolution in the Department of Genetics.

In somewhat similar manner the Division of Plant Biology, established in 1928, shaped itself to embrace the work of six sections, including physiology of growth, photosynthesis or the utilization of solar energy by the plant, classification and its relation to heredity and environment, studies on the influence of aridity, the section concerned with relationships to environment, and one devoted to the history of plants.

Development of the institution illustrates what have seemed to be the needs of organization in attempting to secure the largest

Address given at Cold Spring Harbor, May 31, 1929. *Science*, n. s., vol. 69, no. 1797, pp. 585–588, June 7, 1929.

measure of return in investigation. Recognition of research as in itself an essential human activity had not attained the wide acceptance of the present decade, and much of the effort of the institution was given to support of investigation wherever opportunity might be found. The interest of Mr. Carnegie in discovery of genius or the exceptional man found expression in numerous special grants, designed generally for personal work in specified fields.

With continuing study of opportunities for constructive work it was apparent that, in addition to the discovery of genius, advance of knowledge depends in some measure upon the possibility of bringing into research a degree of cooperation comparable to that which has been broadly characteristic of human relations in the advance of civilization. Out of this idea arose a type of department making possible concentration of effort upon a major problem, and opening the way also to effective advance of genius working in relation to other coordinate interests.

From the earlier trend of the institution toward extreme, and sometimes isolated specialization, the more fully appreciated unity of knowledge in present-day thinking has brought once more a recognition of the interdependence of all scientific groups. Cooperative researches, including the most widely separated departments and investigators, have developed a unity of interest and operation within the institution. They have brought into close relationship many elements which seemed only remotely related in objectives, and were widely separated geographically. In general the community of interest developed is at least as intimate as that which obtains within the spatially narrow limits of a campus. So we see the geophysicist and astronomer make plans for joint spectroscopic study of gases flaming from the inner earth; we find the physicist, chemist and astronomer turning their concentrated interest upon the crucible of the sunspot or the spectra of remote nebulae; in biology the physicist and geneticist unite to wrest the secrets from the chromosome; in another region the plant physiologist, the mathematical astronomer, the paleobotanist, the archeologist, and the meteorologist enter together upon study of varying patterns in the rings of a fossil tree, in order to learn the habits of the sun in radiation of its energy in a remote geological period.

To-day we find the institution utilizing all the major types of ac-

tivity that have arisen in the quarter century experiment of its organization. There are still widely ranging special grants. Great departmental activities still represent concentrated effort in specific fields. The increasing mutual interest among research groups has not diminished the initiative of the individual. With the passing of time the element of broader cooperation within the institution has made more effective both the special concentration on particular projects and the development of that wider view so essential in long-continued research operations.

As the institution developed and research production attained considerable volume, it became clear that one of the greatest responsibilities relates to the making of results available for others. Whether this concern the investigator, the general student, or the intelligent citizen, there is increasing realization that if the treasures obtained are hidden in labyrinths bounded by unmeasured walls of printed pages, they may bring relatively small contribution to the community which makes possible the joy of this work.

In activities concerned with the field of the unknown, it will always be difficult to devise arrangements by which the information secured can be disseminated directly to those for whom they have largest use. But it is at least true that in the work of the institution, each year sees real increase in effectiveness of statement, interpretation and distribution of materials. This applies not only to means used in reaching other specialists of the same field. It concerns as well the extremely important opportunity for communicating the results to students of related subjects, as also to the engineer or applier of knowledge, and to those with interest in knowledge for its own sake.

There has not appeared in these developments a tendency to direct institution activities into the field of education as it is generally known. There *is* expressed the recognition of a responsibility for transmitting information regarding researches in progress in such manner as to attain as nearly as possible full value for the work as it proceeds.

The exhibits presented here to-day for the inspection of our friends illustrate one aspect of our view with relation to interpretation of research. They are the materials used in significant investigations now under way, and are planned to make a simple statement of the problems attacked. They are naturally in the main

obtained from the laboratory at which we meet. They have special value because of the opportunity to see them through the eyes of those who have conducted the investigations. In addition to indicating the character of the questions asked of nature they show the mode of approach in attempting to obtain answers. If the story could always be told as effectively as it is developed here, we should have advanced far in bringing research to a point at which the statement of its results would be at once an extremely effective form of education.

Concrete illustrations of the tendency to relationship among investigating groups of the institution are furnished through several groups of exhibits. In the first building there is illustrated a research on the development of the mouse, and the influences which may affect these changes. It is interesting to note that the early growth stages, showing division of the mouse egg into complex cell-structure, have been furnished by cooperation with our department of embryology in Baltimore.

In the second building the exhibit, expressing the extremely important relation between the thyroid glands and the process of metabolism or energy production, is a joint investigation carried on by Dr. Riddle, of the department of genetics, and Dr. Benedict, of the department of nutrition in Boston. It contributes on the one hand to interpretation of metabolism, and, on the other, concerns that extremely important influence of the endocrine glands which plays so large a part in the later stages of development. By way of the department of nutrition, this investigation has also close relationship to still other researches in the field of nutrition which are conducted under support of this institution by a distinguished group of investigators led by Dr. Mendel at Yale University.

The exhibit by Dr. Blakeslee, in the first or main building, representing through use of the jimson-weed one of the outstanding studies of the mechanism of heredity and mode of development in plants has its intimate relation to much of the research furthered by the institution's division of plant biology. Especially closely does it touch the genetical researches of Dr. Belling, of that group, and the cooperative investigations of Dr. Babcock in the University of California.

The exhibit of Dr. Banta, in the first building, illustrating influ-

ence of various external conditions upon sex and other features in development, is one of the outstanding studies concerning relation between hereditary tendencies and environmental influences. Another institution research of comparable type is that of Dr. Clements, of our division of plant biology. Dr. Banta's investigations are limited to study of a small group of organisms, water fleas, examined by a wide variety of methods, and over a long period. The studies of Dr. Clements concern more especially the relationships of great masses of individuals in relation to their environment under conditions as they are found in nature.

In the Eugenics Record Office on the hill above us, Dr. Laughlin's unique genetical researches in inheritance of physical and psychological characters of the thoroughbred horse make direct contribution toward the study of inheritance of physical and mental characteristics in man.

But the background against which these interesting accumulations of experience in observation of the horse must be projected, is formed by such researches as those on the fruit fly under the hand of Morgan, Metz and many others, on the larkspur as examined by Demerec, on the study of variation in maize, on the chromosomes of the jimson-weed, and through a whole new world of knowledge developing in many institutions engaged in research.

The special studies on human inheritance and development, constituting Dr. Davenport's culminating problem of the Eugenics Record Office, depend not only upon the broad foundation of researches extending from genetics through all biological and physical sciences, but connect us in other directions with a great field of inquiry on specifically human questions, presumably not to be solved solely by study of plants or lower animals.

One of the interesting illustrations showing relationship of this work to that of another institutional activity is found in the cooperation between genetics and early American history in a study of race mixture. On the biological side there are involved the elements of inheritance through the chromosome, and the influence of the ductless glands upon development. The biological researches lead into investigations of mental traits and the consideration of human thinking and emotion, in which science has done little more than to lay out a region where it expects to make progress by the scientific method.

On the historical side of the work we see another group of students slowly but surely bringing together the kaleidoscopic picture of human experience. Essentially it seems an expression of the potentiality of man in nature with respect to change in accordance with law.

While genealogy, as sometimes interpreted, appears to look to the past as a justification for what exists, history tends to see its much longer record not merely as justifying what is, but as the evidence of a great becoming.

History would admit the absence of value in consideration of a past from which there comes no lesson, or of things for which there is no remedy. It is good philosophy, as well as good psychology, to turn away from that which can not be corrected. It is also true that, taking human experience in the large, the joy of living and of being will not depend alone upon the manner in which what lies before us functions at a given moment. Two of the greatest truths in science concern, on the one hand, the unity of nature in the operation of its laws, and, on the other, the evidence that what we call stability of form or function is found only by those who see the universe, or any part of it, as an illumination of experience corresponding to the vision of a wind-swept forest under a lightning flash.

With what we know of nature and of man, it might appear that one who learns to know not only the form and functions at a given moment, but sees also the controlling modes of change, might well become master in the universe.

And finally, as wide as may be the range of these researches and the relationships which I have attempted to sketch—chromosome, mouse, thyroid of dove, horse, man—we find them balanced against each other as complementary elements in method and in point of view. It is through this kind of breadth of vision and mutual support that combined efforts of the many and varied institutions, such as are represented here to-day, may hope ultimately to obtain a clear and verifiable picture of the world about us, and of the place which man has in it.

THE CARNEGIE INSTITUTION OF WASHINGTON

The Carnegie Institution of Washington was founded by Andrew Carnegie in January 1902. A second and revised charter from the Congress of the United States was effective as of May 1904. The Institution is organized under a board of twenty-four trustees, with an executive committee meeting frequently through the year for consideration of policies and specific plans for conduct of research.

The founding of the Carnegie Institution of Washington by Mr. Carnegie was of peculiar significance as an influence directing attention toward the idea that there is an important field for special effort through adding to knowledge, as contrasted with the restatement or transmission of knowledge. The decision to establish an agency for the specific purposes expressed in the Carnegie Institution did not indicate that such activities are either more or less important than educational work. It presented rather a coordinate or supplementary program, which in its operation would naturally gear itself closely to institutions designed initially for the work of education, or for special application of knowledge.

Research had already given clear indication of its superlative importance to future civilization through rapidly increasing demonstration of the fact that available information regarding ourselves and the world about us is only a part of what may be obtained. The idea of pioneering, or of exploration, in the field of knowledge as an activity of such intrinsic importance as to warrant its special support received exceptional emphasis through Mr. Carnegie's contribution.

Established to encourage "investigation, research, and discovery, and the application of knowledge to the improvement of mankind," the methods defined for conduct of business of the corporation were stated in such terms as to permit the doing of what-

In *Forschungsinstitute, ihre Geschichte, Organisation und Ziele*, edited by Ludolph Brauer, A. Mendelssohn Bartholdy, and Adolph Meyer. Hamburg: Paul Hartung Verlag, 1929.

ever might seem properly to advance knowledge and its use for benefit of mankind.

In the early stages of operation, the activities of the Institution were directed toward support of a relatively wide range of subjects, and the grants were commonly for specific projects and for limited periods. An important stimulus to constructive work in many types of agencies seems to have resulted. In time the tendency developed to direct effort toward certain major projects the solution of which required longer periods and greater opportunity for concentration of funds. This movement led to the origin of departments devoted each to its specific subject and under leadership of an investigator bringing exceptional vision and ability. It had become clear that in the elaboration of knowledge many problems of first importance had already attained such complication that their study could be conducted effectively only through the united and concentrated work of groups of individuals. The departments which arose were dedicated to the study of great questions, and gave to groups of individuals the opportunity to advance knowledge in a cooperative effort presenting exceptional possibilities to all engaged in the program.

The system of minor grants for special projects, or to distinguished individuals, was continued, but in many cases advantage was found in relating the problem covered by the special grant to work of a department of the Institution especially fitted to cooperate with the investigator. The operation of this plan meant commonly a contribution consisting both of funds for support and of assistance by an actively investigating agency.

Continuous study of the possibilities in research through the Institution has been necessary, as also the recognition of constant change in requirements of the country and in opportunities for furtherance of investigational work. The experience of the Institution during the quarter century of its effort to serve as a special means for advancement of knowledge, furnishes material which will have real value in future study of the place of research in the scheme of human activities. It is still too early for anything more than the most general statement regarding the meaning of the accumulated data.

In later stages of the Institution's work, real advantage has appeared in a close relation between departments, comparable to

that which had developed in many instances between departments and individual investigators. The favorable features of continuous, concentrated effort upon specific subjects in departments have been supplemented by active interest and support of related agencies within the Institution and the cooperation of many other organizations.

Many significant investigations have developed within the Institution through cooperation and mutual support of departments or other agencies joining in attack on problems in which there are common objectives, but for which no single group is equipped to handle all researches necessary. Illustration of such combined effort is furnished by a program of the Geophysical Laboratory and the Department of Terrestrial Magnetism, initiated for study of the effect of high pressures upon the critical temperatures of magnetization of materials contributing largely to the mass of the earth.

A further plan for cooperative study now under way is illustrated in the work of a committee, representing two departments of the Institution with investigators from outside agencies, brought together for the purpose of research on physical features of the surface of the moon. The astronomer interprets the moon by means developed through long years of careful study of its surface. The physicist and mathematician approach the problem as experts on physical laws as they are expected to operate. The geologist, volcanologist, geophysicist, and physiographer interpret the surface of the moon in the light of knowledge acquired from corresponding studies of the earth.

The Institution today contains all of the elements that have arisen in the course of study of its problem. There are still widely distributed special grants. The greater departmental activities still represent concentrated effort in specific fields. The increasing mutual support has not diminished initiative of the individual or of the group, but it has added an element which with the passing of time becomes more and more valuable, both in effort to concentrate upon special projects and in keeping that view of the larger field so desirable in long-continued researches.

In the present organization of the Carnegie Institution the major researches are grouped in twelve departments or divisions with which are associated many specific investigations not of the departmental type. These divisions are the following: Embryology,

Genetics and Eugenics, Nutrition, Nutrition and Vitamin Chemistry, Plant Biology including the Desert Laboratory, Tortugas Marine Biological Station, Geophysical Laboratory, Seismological Research, Terrestrial Magnetism, Mount Wilson Observatory, Meridian Astrometry, Early American History including Archæology, and Historical Research. The sections of the work of the Institution differ in organization and in type of objective. Administratively they are designed to give effective concentration of effort upon critical problems, and to permit cooperation in a wide range of scientific effort. Inasmuch as the objective of the Institution relates to the solving of problems of varying types, a difference among the administrative units is to be expected.

Particular care has been taken in the selection of problems. The number of matters which might be investigated is infinite. Perhaps the number to which investigation might profitably be directed is also infinite. But it is expedient in each period to consider what questions may have largest use in furtherance of knowledge for the benefit to mankind at that particular time. In accordance with the thought of Mr. Carnegie there has also been careful search for the individuals best fitted in temperament, training, and interest to undertake investigations of the highest type.

Continuing study is given to understanding of means by which the Institution can most advantageously make the results of its work available to all scientific workers and to the public. Publications of the Carnegie Institution of Washington are designed to present in concise form the results of researches not finding their way to the public through other natural channels of scientific literature. In this series 577 volumes have been issued on subjects ranging over the field of scientific and humanistic research. In addition to publications issued through these "Publications of the Carnegie Institution of Washington" a quantity of results at least of equal significance has appeared through other publications.

While there can be no doubt that the making of accurate and clear record of all data secured is our first duty, and is the basis for future use of the results secured, it becomes increasingly important to obtain such statement of conclusions reached as will make them available in their simplest form, and in their clearest relationship to other knowledge, for use both of specialists in all fields of science and of the public.

The scientific literature of the world could easily become so technical in its various departments that advantages of special researches would in large measure be lost to workers in other fields. Such a situation would not merely deprive the world in some degree of the benefits of specific researches, but it would prevent the investigator from obtaining for his own use data required from other fields. It has, therefore, been recognized as desirable that, in addition to precise records concerning special investigations, there be made available such data as will present the results in easily interpretable form to workers in other fields of science, as also to the public.

Recognizing that efficiency of research must not be sacrificed by reason of attempt merely to popularize results, continuing study has been put upon the problem of how we can best bring contributions from Institution activities into position where they may have the largest value to the scientific and general public.

Carefully prepared releases, arising from accounts of researches furnished by the investigators, and appearing in form acceptable to the public press, have served as a means of extending clear statements regarding work in progress to many millions of persons. There is reason to believe that these statements serve as an important medium for transmitting information regarding results obtained, both to the lay public and to the scientific world.

One of the important responsibilities of the Institution has to do with making its completed work fully available to scholars and to the world. In educational institutions new knowledge receives relatively large and almost immediate use through contact with individuals early in life who are securing information and training. In a research institution new knowledge may be technically of record through publication and yet have relatively little application for a considerable period. Frequently the time elapsing after discovery, before it attains application, may be measured in decades or longer periods. The Institution is continuously aware of its responsibility in this field, and every effort is made to see that the results of work come into as full use as possible in all of the directions in which the new knowledge is properly applicable.

With the tendency of education to express itself more and more clearly through development of creative or inspirational aspects of thought, question is raised whether in a research institution en-

gaged in presenting the results of discoveries there is not offered one of the most interesting opportunities for education in a limited field. While the research institution does not attempt to cover the whole field, it may have a responsibility for telling a broadly significant story by use of that portion of the field which happens at a particular time to be especially useful.

The exhibition of results coming from current research in the Institution as presented at the annual meetings furnishes one important means for expressing to members of the Institution and to the public the trend of development in activities of the Institution as a whole. On this occasion directors and investigators of the Institution examine and discuss results from research in all departments and divisions of the program. The attempt to make the exhibits represent outstanding attainments in study of the most important questions to which the departments are devoted means that there is opportunity for consideration of the basic problems of each group in relation to those of other departments, as well as to the work of other organizations.

Such opportunity to see the simplest and clearest statement of results of research in all departments has been of much value through its influence in opening the way to significant cooperative relations. At this time of highly specialized science it is not only extremely important to carry each investigation to the uttermost attainable limit, but it is more and more desirable to know the extent to which information on a given subject may find its interpretation through organized knowledge in other fields.

Provision has been made by the Institution for various types of insurance. An Insurance Fund established to cover property damage has increased to such an extent that annual interest upon it now almost equals the sum formerly appropriated for each year.

The Institution has also made provision for annuity and life insurance for regular members of its staff through cooperation with the Teachers Insurance and Annuity Association of America. In order to provide adequate retiring allowances for members who were already advanced in age when the Annuity Plan of the Institution was put into effect in 1919, a special Pension Fund was created from which supplementary annuities might be drawn under specific regulations. Payments from this fund are also made to cover contributions by the Institution toward premiums upon an-

nuity policies taken out by members of the Institution with the Teachers Insurance and Annuity Association.

In the course of the past four years the Institution has had under consideration questions touching the desirability of protecting, for use of investigators and of the public, such patentable devices and equipment as may originate through researches undertaken by the staff of the Institution. The problem was brought forward by reason of need for considering protection to a simplified form of respiration apparatus invented by Dr. Benedict, Director of the Nutrition Laboratory, and Mrs. Benedict, constructed for the purpose of measuring oxygen consumption in research on human metabolism. In May 1923, the Institution defined its position by resolution as follows: ". . . it is the intention of the Carnegie Institution of Washington that any new and useful inventions or discoveries which may result from researches financed by the Institution shall be dedicated to public use and that for this purpose all patents thereupon should be taken out by, or for, or assigned to, the Institution." The Institution by definition of its plan may not profit financially from such patents or from the licensing of manufacturers to produce instruments thus protected.

The plan for protecting certain types of results of research in the interest of the public has advanced to the stage of full application through licensing of approved agencies to produce appliances which have been patented. In five departments of the Institution instruments of singular importance in the conduct of research have been developed, for which there has been general demand for protection by patent. The Institution's program in this connection involves provision for carefully controlled production under license, after assignment of patent rights to the Institution, and after public declaration of the purpose and policy of the Institution in handling such inventions.

A number of other research organizations are confronted with similar problems, and collateral studies are being undertaken which will give additional information regarding development of appropriate methods of procedure in dealing with patents obtained in the conduct of research.

The special activities of the Carnegie Institution may to best advantage be considered by outlining the types of problems and method of operation of certain of the larger groups of researches.

Department of Embryology

In December 1914 the establishment of a Department of Embryology was authorized by the Board of Trustees. The researches are conducted at the Johns Hopkins Medical School in Baltimore.

When a program for the study of human development was visioned by the Trustees of Carnegie Institution, decision was made between a detached institution as against one associated with related activities already in existence. The wisdom of adoption of the latter policy becomes more and more evident as the years pass.

Multiple contacts are not necessarily detrimental to the growth of an effective individuality; they, on the contrary, provide the opportunity for its unlimited development. This policy has made possible the establishment of close associations with other Departments of Carnegie Institution and with various laboratories of the Johns Hopkins University and Medical School and particularly the Department of Anatomy.

Similar relations have developed between the Department and embryological laboratories in other universities, making possible cooperative endeavours that could not otherwise be accomplished. Another type of contact arises from natural relation to the general medical profession. Each year about 600 embryological specimens are received for examination and diagnosis. By examining such a large number of specimens the staff has obtained experience and data that enable it to give expert opinion on such matters as the determination of age, sex, race, anomalous development, pathological conditions and, to some extent, the cause of the abortion or defective condition when such occurs.

In performing this service for the physician the Department in return receives valuable clinical information from him. Thus it has been learned that the abnormal specimen frequently reveals important facts regarding normal development, and of course it is only through the physician that the material on which human studies are based can be obtained.

The chief researches of the Department are concerned with human embryology and center about its large collection of human embryos, now totaling over 8,000. This collection is unique in both magnitude and importance, and unceasing efforts are being made to increase it through the cooperation of the medical profession.

Extensive study is being made of the external form of embryos under thirty millimeters in length with a view to dividing this period of development into stages and establishing a norm for each stage.

As a supplement to this study, carefully planned measurements have been made of older fetuses and correlated with the weight of the body at the different weeks of fetal life. This makes it possible to determine with greater precision the age of an embryo and also serves to throw light on anatomical variations and racial differences in anatomy concerning which we have been heretofore almost wholly ignorant.

The anatomy of the human embryo, our knowledge of which has hitherto been fragmentary, is now being systematically studied at its different stages of development as a routine activity of the Department. Considerable attention is also being directed to the pathological aspects of embryology and their bearing upon fertilization, teratology, and the causes of abortion and sterility.

In addition to the work on human embryology, numerous investigations on related subjects are in progress. Reports on cytological studies have already been published and others are under way which will form a groundwork for a better understanding of the histology of the embryo. Advantage has been taken of other embryonic forms, thus making possible the adoption of experimental procedures and observations upon living tissues. The introduction of the methods of tissue culture has resulted in notable progress in the field of experimental cytology.

A colony of macaque monkeys has been installed for the purpose of extending embryological investigations into a primate form approximating man as closely as is feasible in an experimental animal. Researches on these animals will concern both structural and functional development and will embrace the more fundamental aspects of the physiology of the developing nervous system, the necessary foundation for an understanding of the factors involved in primate behavior.

Department of Genetics

Research in biology was one of the first subjects to receive consideration from the Institution, and a plan for a station devoted to experimental evolution, submitted by Professor Charles B.

DAVENPORT, was approved in December 1903. Early in 1904 a tract of land of about nine acres, at Cold Spring Harbor, Long Island, N. Y., was leased for a term of fifty years; the erection of a main laboratory was soon begun and the station was formally opened June 11, 1904.

In October 1910 Mrs. E. H. HARRIMAN established the Eugenics Record Office at Cold Spring Harbor, purchased a farm of about eighty acres with buildings near the Station for Experimental Evolution and in 1913 erected a special office building. On January 1, 1918, Mrs. HARRIMAN transferred the office and farm to the Institution and provided an endowment fund of $300,000 toward its maintenance.

The work in genetics comprises investigation of the laws of inheritance in plants, animals and man; of variation in organisms; of the physiology of reproduction and development; the nature of sex and, in general, the factors of organic evolution.

In experimental evolution the following investigations have been conducted: the germ-plasm, its architecture, its mutation, the interactions of the chromosomes; genetics of Datura (jimson weed) and flies (Drosophila and Sciara); the physiology of reproduction, growth and development with special reference to sex, its essential nature and its experimental control, and to the endocrine glands as controllers of development.

NUTRITION LABORATORY

The Nutrition Laboratory has been devoted to a group of extremely difficult questions in which it is now possible to bring to bear an extraordinary technique, worked out with extreme care both theoretically and practically, for study of the energy developed by the human machine. An examination of the relation of the problem to various activities within the Institution by the Director, Dr. BENEDICT, has brought out the fact that the same type of question has arisen in various forms in investigations by many departments.

Relation between the work of Dr. BENEDICT and that in other divisions of the Institution has resulted in real benefit to the researches in all groups of cooperating investigators. Among the joint studies in this field are those of Dr. BENEDICT and Dr. RIDDLE, of the Department of Genetics, on relation of the thyroid to metab-

olism in study of development in the pigeon. Corresponding cooperative arrangements have been made on study of enzymes, with Dr. H. C. Sherman, Research Associate of the Institution at Columbia University, and with Dr. L. B. Mendel, of Yale University, in researches on changes in growth of the rat produced by variation of food. Similar investigations have also been considered by Dr. Benedict in cooperation with the Carnegie Foundation on problems concerning physiology of exercise in studies of athletics, and with the Division of Early American History in study of metabolism in various peoples.

As illustration of the extent to which cooperative arrangements may be developed, Dr. Benedict has recently made arrangement with the Department of Terrestrial Magnetism through which members of that staff have been trained to make tests of metabolism of peoples in the various countries in which stations of the Department of Terrestrial Magnetism are located, and in regions where the ship *Carnegie* will touch in the course of the three-year cruise upon which it has recently entered.

Division of Plant Biology

The many important activities in the field of the plant sciences have been brought together as a Division of Plant Biology. It was not the intention through setting up of the present organization to extend the work of the Institution so as to cover the whole of plant biology. It was rather the purpose to obtain a somewhat better visualization of the field, and of the opportunities for effective cooperation among the interests concerned. The grouping is designed to give opportunity for maximum unity in operation of the diverse interests involved, and at the same time to increase the possibilities of effective work for each group.

The division is composed of the following sections: photosynthesis, physiology and plant growth, desert laboratory studies, plant ecology, taxonomic relations, and palæobotany. Each section is under guidance of a leading investigator. Through cooperation of Stanford University a lease for five acres of land has been obtained on the campus of the University. A new laboratory is to serve as headquarters for the Division, and for conduct of researches in photosynthesis, taxonomic and ecologic problems, and other subjects.

The groups of researches within the Division will operate at the localities at which the work can be conducted to best advantage. So, the Desert Laboratory at Tucson, Arizona, will continue as the point at which investigations most effectively conducted under arid conditions can be carried on with advantageous laboratory facilities, and with utilization of a diversified "campus" covering approximately 800 acres of extremely interesting desert country remaining completely protected under primitive conditions.

At the laboratories in Carmel, California, the program of researches on the physiology of tree growth, which has made significant contribution toward interpretation of the structure and physiological processes of the tree, is being extended under direction of Dr. D. T. MacDougal.

Intimate relation of the sections of the Division to each other will make possible in increased measure the utilization of the highest technique of each of the groups for solution of problems of the whole Division.

In organization of this Division, there has been developed also a closer relation between investigators in the fields represented and those in other departments of the Institution. Especially is this true in relation to the Department of Genetics. It thus becomes possible to develop an intensified program of plant research involving the present Division of Plant Biology, the plant geneticists of the Department of Genetics, and associated investigators who through their researches in genetics are already cooperating with the Division.

Tortugas Laboratory

The biological station, established by Dr. Alfred G. Mayor on the Dry Tortugas keys seventy-five miles west of Key West, was occupied as a point of exceptional interest, at which tropical fauna and flora could be found in a region bordering the Gulf Stream.

Until his death in 1922 Dr. Mayor was indefatigable in planning the work, in securing and organizing the facilities, and in pursuing his own researches, notable among which is his study of the jellyfish of the world.

Eloquent testimony to his inspiring leadership is found in the

hundreds of short monographic studies made and published during his lifetime and in the more extensive investigations, continuing over many years, such as that of VAUGHAN, on the geology and palæontology of the West Indies; TENNENT, on the normal growth of sea urchins, their development from egg fragments and their hybridization; SCHAEFFER, on marine amoebas; and LONGLEY, on the coloration of fishes.

At the time of the death of Dr. MAYOR, many problems of interest were being studied intensively, and work has been continued along the lines then laid down. The program of studies set up by Dr. MAYOR rested fundamentally upon his personal influence. The group of investigators was stimulated by his enthusiasm and guided by his exceptional vision. When Dr. MAYOR's work ended there was clearly question whether at such a remote locality it would be advisable to continue these activities beyond the steps needed in carrying to completion specific researches under way.

With the cooperation of the investigators already concerned with special problems at the Tortugas Station, and with assistance of Dr. W. H. LONGLEY, as Executive Officer, there was put in operation a plan for utilization of the station for the purposes defined by Dr. MAYOR, plus the opening of opportunity for use of these advantages by investigators of the Institution or cooperating agencies when there are problems which can be considered to better advantage at Tortugas than at any other locality. On this basis the Institution has been able to assist a group of researchers especially desirous of utilizing the advantages of this location. The result has been gradually increasing development of important investigations, until today the station has reached its full capacity.

Geophysical Laboratory

One of the first projects suggested to Carnegie Institution, upon its organization in 1902, was that of the study of the causes which bring about movements and warpings in the earth's crust. A distinguished group of scientists, commissioned to advise the Institution, spent four years in considering the general direction which this research should take and the manner of its pursuit.

This committee reported that geological studies of the rock record of the earth's past, heretofore made, had been directed chiefly to

reading and mapping the record, but that the record needed to be interpreted on broader and deeper lines based on more profound knowledge of physical laws.

The committee also suggested that bound up with such a study there was a group of intricate questions of a chemical and chemico-physical nature such as the flow of rocks, the origin and destruction of minerals, the function of water and gases included in minerals, the origin of iron deposits and the effects of temperatures, pressure, and tension upon chemical changes in rocks.

The committee also pointed out that questions relating to the earth's outer part were inseparably connected with those relating to the earth's interior involving, in consequence, the most extreme and the least understood conditions, knowledge of which could be gained only through laboratory experimentation.

Further consideration brought out even more emphatically that a laboratory was needed where carefully controlled experiments could be conducted on a large scale. A report, as formulated at the time, asserted that geologists want information upon all the phenomena connected with the transformation of liquid rock into crystallized rock and of crystallized rock back into a molten state.

These investigations of the needs of geophysical research made more than twenty years ago coupled with specific recommendations offered at the time led directly to the building and equipping of the present laboratory which was opened on June 7, 1907.

Continuously for twenty years work has gone forward along the lines originally suggested. Six hundred and sixty-nine published papers and monographs record the results of the investigations of a staff of specialists now numbering twenty-four.

The investigations undertaken have included a considerable number of silicate solutions, corresponding to particular groups of rock-forming minerals, including some in which water and carbon dioxide have been associated.

The type minerals made in the laboratory are purer than those found in nature, a fact which gives a certain degree of finality to studies of their relations when compared with earlier studies of natural minerals, which in many cases it was necessary to repeat whenever more typical specimens were discovered. It has also proved practicable to develop a complete system of methods for identifying mineral crystals of very small size, such as are usually

obtained in the Laboratory where the time available for crystal growth is so much shorter than the period of growth in nature.

Investigations have also been made of the quantity of heat involved in mineral reactions and in the change of state from liquid to solid, in which the precision obtained is entirely comparable with that usual in like investigations of salts at ordinary temperatures; also in the study of solutions it has proved possible to show the manner of separation in magmas through differences of density between the minerals first to crystallize and the remaining magma.

It is proposed to pursue this subject rather extensively, with correlative studies of natural occurrences. It has even proved practicable to approach certain active volcanoes and to make collections of the gases set free there, and so to obtain a clue to the reactions between these gases, the amount of heat developed thereby, and the possibility of accounting for the maintenance of volcanic vents through the release of this heat.

Studies of atomic structure in crystals have been undertaken very recently in order to obtain for mineralogy information about the intimate structure of the forms of matter with which it deals, comparable with like determinations in modern molecular physics.

The study of compressibilities of rocks and minerals has been attempted, and in general the effect of pressure upon all the problems of mineral and rock formation, so far as this can be done with means now available, and many other researches related to these have likewise been successfully undertaken.

Seismological Research

Working independently, but in close cooperation with the Carnegie Institution, many agencies, including the United States Coast and Geodetic Survey, the United States Geological Survey, University of California, Stanford University, and California Institute of Technology have moved in recent years to organize new activities in seismological research. There can be no doubt that recent marked progress in seismological investigation is only the beginning of a great advance in this field. It will lead both to outstanding scientific contributions, and to means of avoiding such dangers as may have menaced life, property, and the comfort of living in parts of the earth involved in present processes of crustal movement.

The central station for research in this field has been located in Pasadena, California, where extremely favourable arrangements for cooperation have been established. California Institute has added to its equipment a building for seismological research situated on a site especially adapted for such investigations. Plans have been worked out with great care, in order to meet as fully as possible the needs of fundamental research and effective educational work in this field. This building is occupied by Carnegie Institution in carrying forward its seismological investigations in cooperation with California Institute. The City of Riverside has entered into an agreement with Carnegie Institution through which it furnishes site and building for a seismological station and covers fixed charges of operation. Carnegie Institution is to utilize this station for conduct of seismological studies, involving general investigation of earthquake problems. Other cooperative arrangements have been made with the Santa Barbara Museum, which has constructed most favourable quarters for location of instruments and cooperates in furtherance of the investigation.

Department of Terrestrial Magnetism

The Department of Terrestrial Magnetism was formally established in 1904 under the auspices of the Institution in general accordance with a plan for an "International Magnetic Bureau," submitted by Dr. Louis A. Bauer in 1902. This plan had received the support of leading investigators in terrestrial magnetism and atmospheric electricity, at home and abroad. The purpose of the proposed bureau was "to investigate such problems of worldwide interest as relate to the magnetic and electric conditions of the earth and its atmosphere, not specifically the subject of inquiry of any one country, but of international concern and benefit."

The following were designated as some of the chief problems which might be undertaken: A magnetic survey of ocean areas and unexplored regions; international observations of the manifold variations in the magnetic and electric conditions of the earth, inclusive of its atmosphere; and observations pertaining to terrestrial magnetism and terrestrial electricity in ocean depths and atmospheric regions.

In the plan of the bureau, reference was made also to other problems, such as the correlation of local and regional disturbances of

the magnetic needle with geological and physiographic features, and the correlation of magnetic and electric disturbances with solar and allied phenomena.

The first project of consequence to be undertaken was that of the making of a general magnetic survey of the earth, especially of ocean areas.

It was decided first to make a magnetic survey of the Pacific Ocean, as, for that ocean particularly, magnetic data (compass direction, dip of the magnetic needle and strength of the earth's magnetic field) were required for the correction of magnetic charts then in use by mariners and by investigators for their studies. Excepting data obtained on the voyage of the *Challenger* (1872–76), the North Pacific Ocean in 1905 was nearly a blank as regards magnetic observations.

Accordingly, from August 1905 to May 1908, cruises were made in the Pacific Ocean with the brigantine *Galilee.* The vessel covered an aggregate of 63,834 nautical miles, or 73,511 statute miles, completely crossing the Pacific a number of times from the American to the Asiatic Continent and from Alaska to New Zealand.

The success of the work of the *Galilee* and the importance of the errors disclosed in ocean magnetic charts led the Institution to authorize the construction of a non-magnetic ship, the *Carnegie*, specially designed for magnetic work in all the oceans. This vessel was launched at Brooklyn, New York, June 12, 1909.

Six cruises have been completed in furtherance of original plans. The data resulting from these cruises include declination observations at 3,316 points, both inclination and horizontal-intensity observations at 2,147 points, and atmospheric-electric observations on 1,594 days, with extended series to determine diurnal variations on 85 days.

The sailing of the ship *Carnegie* from Washington on May 1, 1928, initiated the seventh cruise of this extremely interesting vessel, devoted primarily to observations on magnetic and electric variations but now extending its work more widely to reach correlated aspects of physical oceanography. The activities, in addition to those in terrestrial magnetism and atmospheric electricity, will range through physical studies of the atmosphere, chemical analysis of sea-water, deep dredging for physical and biological purposes, and mapping of the sea floor.

The observational work of the *Carnegie* is correlated with an extremely careful program of researches centering upon the general problem of the earth as a magnet.

The work of the Department of Terrestrial Magnetism as expressed in the voyage of the *Carnegie* is only one phase of the observational program having to do with collection of data in study of physical problems of the earth.

The accessible land surface of the earth, as well as that of its oceans, must be included in the general survey to map completely its magnetic field and to supply material for disclosing the character and significance of the continuous change in the subtle forces concerned. Accordingly, in the twenty-two years from 1905 to 1926, about 150 magnetic exploratory expeditions have been sent out to remote and little-known regions and to countries in which either there were no established organizations for magnetic work or in which the existing agencies could not undertake the desired work and welcomed the cooperation of the Department.

At two permanent observation stations on approximately opposite sides of the earth—one high in the Andes at Huancayo, Peru, the other at Watheroo in Southwestern Australia—there are being conducted experiments of unique interest directed toward investigation of the natural electric currents flowing in the earth, and of their relation to phenomena of the earth's magnetic changes.

As much as may be learned by these methods, it is clear that the ultimate problem of the Department can be solved only when these researches are related to fundamental investigation of the structure and magnetic properties of matter. To this end there is under way a series of intimate laboratory studies of magnetic phenomena. These investigations are directed most intensively at the present time to consideration of certain aspects of atomic physics. Special effort has been made to approach the problem by paths somewhat different from those heretofore followed. The laboratory investigations are conducted in correlation with researches undertaken by many other institutions, and in collaboration with a number of associates representing other scientific agencies of this country and Europe.

The Department has been active in developing cooperative work with other divisions of the Institution and with related agencies.

Especially significant have been the investigations set up jointly by the Geophysical Laboratory and the Department of Terrestrial Magnetism on influence of high pressure and high temperature upon magnetic properties of materials in the interior of the earth, and those conducted in cooperation with Mount Wilson Observatory in study of the relation between magnetic phenomena of the sun and variations in the magnetic and electric conditions on the earth.

Mount Wilson Observatory

The Mount Wilson Observatory was established in 1904, after a careful test of atmospheric conditions at various promising points in California, Arizona, and Australia. The site selected is on the summit of Mount Wilson, in Southern California, 5,714 feet above sea-level.

The laboratories, instrument, and optical shops, and the offices for the measurement and reduction of astronomical and physical photographs and for other activities not requiring the favorable atmospheric conditions of the mountain station are situated in Pasadena. From this point the summit of Mount Wilson, about fourteen miles distant, may be reached in two hours by automobile.

The purpose of the Observatory is to study the structure of the universe and the evolution of celestial bodies. The observational program comprises series of closely related investigations, chosen so as to aid in interpreting one another and all directed toward a common objective. The underlying scheme is based upon an intensive study of the sun, the only star near enough to the earth to be examined in detail.

Three telescopes are provided on Mount Wilson for solar observations: The Snow horizontal telescope, the 60-foot vertical tower telescope, and the 150-foot tower telescope. These three telescopes are used regularly for photographing the sun's surface and its atmosphere, and for investigation of the solar vortices and magnetic fields connected with sun-spots, the general magnetic field of the sun, the law of the sun's rotation, the displacement of solar lines and their bearing on the Einstein theory of relativity, etc. The results thus obtained have been of great service in the initiation and interpretation of researches on stars and nebulæ.

Three other telescopes, each with equatorial mounting and pro-

vided with special accessories, are employed for the night observations. One of these is a 10-inch Cooke photographic refractor, of 45 inches focal length, permitting large areas of the heavens to be photographed on a single plate. The others are reflectors of 60 inches and 100 inches aperture.

The great light-collecting power of the 100-inch telescope permits the faintest known stars to be photographed directly on the sensitive plate and makes it possible to study a large number of objects with the aid of spectrographs of high or low dispersion. This telescope is also especially adapted to the photography and spectroscopic examination of nebulæ, whose minute details of structure are beautifully revealed by its large-scale images.

These telescopes, in use throughout every clear night, are also employed for the photographic measurement of the trigonometric parallaxes of stars and nebulæ, the determination of stellar motions in the line of sight, the measurement of the distances and intrinsic brightness of stars by means of the spectroscope, the determination of stellar magnitudes, the investigation of starclusters, the scale of the stellar universe, the detection of changes in nebulæ and the measurement of their distance, and a great variety of other studies.

Special attention is given by the Observatory to the invention and use of new instruments and methods and the application in astronomy of devices previously employed only in other branches of science. A notable illustration is the recent successful application of Michelson's interferometer to the measurement of the diameters of several stars, some of which have been found to exceed 200,000,000 miles.

Another cardinal principle in the policy of the Observatory is the imitation and interpretation of celestial phenomena by means of laboratory experiments. The physical laboratory in Pasadena is especially well equipped for such research.

The completion of two extensive and important investigations which have been in progress during a considerable portion of the life of the Observatory has been one of the noteworthy results of the past year (1928). The first of these is the *Revision of Rowland's Table of Solar Spectrum Wave-lengths*. With the publication of this valuable collection of material the astronomer or physicist will have at his command an accurate system of wave-lengths for about

22,000 lines in the solar spectrum, together with a great amount of data relating to the classification of these lines according to temperature, pressure, and excitation and ionization potentials, which recent advances in physical theory have made possible.

The *Revised Table* also includes an extension of *Rowland's Table* to longer wave-lengths, a comparison of the intensities of lines in sun and sun-spots, and a complete revision of all identifications, which has added very greatly to the number of lines of elements recognized as present in the sun. In the course of this work the presence of six elements not known previously in the sun's atmosphere has been satisfactorily established.

The second investigation is the *Mount Wilson Catalogue of Stars in the Selected Areas*, now completed. This brings to a close a series of related investigations which began in 1909. The catalogue includes measures of brightness of about 68,000 faint stars in sample regions distributed uniformly over the sky. The resulting magnitudes serve the two-fold purpose of providing standards for the measurement of the brightness of stars in neighboring regions, and material for a new discussion of the distribution of stars. This discussion, which bears directly on the structure of our system of stars and the position of the sun within it, has also been completed.

Department of Meridian Astrometry

The Department of Meridian Astrometry was established for the purpose of preparing a general catalogue of positions and motions of stars out to the seventh magnitude. This work, established in March 1907, is rapidly approaching completion. Publication of the *San Luis Catalogue*, just issued, marks one of the first divisions of the work to be finished.

This catalogue contains the positions of 15,333 stars, mostly situated in the southern hemisphere; all the southern stars to the seventh magnitude, together with many fainter ones, are included. It represents the completion of the first step toward the fulfilment of a larger plan, the formation of a *General Catalogue* of positions and motions of over 30,000 stars from pole to pole.

The contribution made by this study is of great significance in many fields of astronomy, giving as it does the most precise determination of position of a multitude of stars. In the results of this

work lie important data needed in consideration of movements of the stars, and giving certain phases of information required in forming estimate of the true nature of our own star system.

The supplement to the *San Luis Catalogue*, the *Albany Catalogue* which includes a similar list of stars principally located in the northern hemisphere, is well on its way toward completion, and work on the *General Catalogue* is in progress.

The magnitude of the task in this department is indicated in the statement that preparation of the catalogues has occupied a considerable staff for twenty-one years. During this period approximately $708,500 has been expended for the work.

Following completion of the investigations in this project, it is desired to present along with the *General Catalogue* a summary of collateral results attained during the course of these studies.

Early American History

The specific investigations undertaken by the Institution in American archæology have involved on the one hand intensive detailed investigation of materials and, on the other hand, an effort to bring the results secured into relation to the larger body of information representing movement of events in early history of this hemisphere. These studies have been undertaken with the hope that through them there might be derived some suggestion of laws which have governed in development of the varying types of peoples and cultures in America.

There has been need of opportunity for interpretation of materials obtained through our own studies in the light of outstanding investigations on the American problem in other regions. For the purpose of better definition of program, both in the sense of more intensive study of detail and with a view to obtaining the broadest understanding of our results, attempt has been made to restate our plans with expectation that this action will give a relatively large return for an equivalent effort.

Ample justification for adherence to the fundamental plan of the Institution in furtherance of historical studies in Middle America is given in the results of work in recent years at Chichen Itzá, Yucatan. These researches bring out much new material bearing upon the life, culture and art of the Maya people. The data secured give added strength to the view that early Americans made

a cultural contribution which will be of value to the world as a whole, and of which the aboriginal peoples of America may justly be proud.

In connection with the plans for continuing study on problems of Middle American civilization, it is planned to carry forward a program involving not merely architecture and art, but comprising as well a careful examination of the development of this civilization in relation to its environment. To this end it is important that studies be made ranging from the general geology, ethno-botany, and ethno-zoology of the region up to and including the story of those specific difficulties which have beset the human group as expressed in what may be called its medical history. Through this consideration of the record of human development we may expect to relate the history of the Maya people to problems of the present day, in such manner that the historical evidence will contribute directly toward interpretation of questions of the present and future.

In furtherance of the projects concerning Middle American history, it has also been considered important to keep continuously in view the relation of questions touching origin and development of the Maya people to those broad and fundamental problems which have to do with history of the earliest civilizations of Central America, Mexico, and southwestern regions of the United States. To this end the basic studies already far advanced by Dr. A. V. Kidder and Mr. Earl Morris are being continued, as a part of the background against which research on early relationships and origins of Middle American peoples must of necessity be projected. The plan, as now worked out, represents one of the most interesting researches in the wider aspects of history that has been developed in America.

Department of Historical Research

In February 1903 the Institution, upon suggestions received from the American Historical Association and from its own advisory committee on history, organized a Bureau of Historical Research, under the directorship of Professor Andrew C. McLaughlin. Professor McLaughlin continued his services as Director until October 1, 1905, when he resigned and was succeeded by Professor J. Franklin Jameson. At the same time the present designation

of the Department was adopted. Dr. Jameson resigned in July 1928 to accept the chair of American history at the Library of Congress.

This Department is chiefly occupied with the preparation of publications intended to assist investigators in American history. It has issued reports on materials for American history, aids to their use, and guides to the important collections for which no adequate guides have previously been published. In addition to work in American archives, a large part of the studies of the Department has consisted of exploring and cataloguing the copious materials for United States history contained in foreign archives. In addition to these guides to sources, the Department is also preparing several series of volumes of important material for American history, such as the Proceedings and Debates of the British Parliaments Respecting North America (to the year 1783), Letters of Members of the Continental Congress respecting its transactions, European treaties having a bearing on American history, materials for the history of negro slavery in America, a collection of the correspondence of Andrew Jackson, and an Atlas of the Historical Geography of the United States.

The organization of opportunities in research for the specific purpose of advancing knowledge will represent one of the great responsibilities of the future. The experiment of the research institution effectively organized, and in proper touch with the community, will be one of the most interesting in the field of constructive agencies. There is no activity for which one could predict a larger return for effort in later generations. With the multiplying problems of the world, the future of mankind with reference to its resources, its organization, and its active interests will depend in considerable measure upon our ability to bring forth new information through investigation and to apply this knowledge for human use.

OPENING THE AUDITORIUM AND EXHIBITS BUILDING OF THE MOUNT WILSON OBSERVATORY

PART I. INTERPRETING THE RESULTS OF RESEARCH

The new auditorium and exhibits building, erected at the site of the Observatory on the summit of Mount Wilson, near Pasadena, California, was formally dedicated on the evening of June 14, 1937. Guests were invited to inspect the exhibits during the early evening, later they convened in the auditorium where they were addressed by Dr. John C. Merriam, President of Carnegie Institution, and Dr. Walter S. Adams, Director of Mount Wilson Observatory. Upon conclusion of the addresses opportunity was given to visit the 60-inch and 100-inch telescopes, both of which are located nearby, and to witness a demonstration of the way in which these great instruments are used by astronomers.

Erection of a building suitable for lectures on the work of the Observatory and for permanent exhibits illustrating results obtained came in response to the great increase in the number of visitors who wished to learn about the operations, methods, and discoveries of an astronomical observatory. The building is also a response to the policy of Carnegie Institution which seeks in all of its activities to give the public a clear understanding of what scientific research is accomplishing.—Editor.

Initiation of a program involving interpretation of results of research from Mount Wilson Observatory by means of an auditorium and an exhibit room will raise many kinds of questions, depending upon the person interested. Some will inquire immediately: Why research? Is it a necessity, or only a luxury, or a plaything? Others, who may recognize the value of research, will inquire regarding interpretation of the results. In order that what I say may connect the principal aspects of this story, it is perhaps worth while to devote at least a few words to the significance of research itself.

Importance of Research

In many conversations on this subject, such as one might expect to develop at Washington in a period like the past four or five years,

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the answer has been given through suggestion that if the country needs to investigate its resources in order to guarantee the future, it is important to realize that one of the things upon which we are most dependent is organized knowledge in the form of science.

The movement which we call conservation is devoted largely to protection and to definition of the best use for materials which have been the foundation of our prosperity. It is quite clear that we shall not be able to increase the amount of many substances excepting perhaps by highly specialized applications of scientific knowledge. It is true that we may develop materials which can be substituted for coal or oil, but there will be difficulty in extending the available quantity of iron. Most of present-day conservation consists of intensified application of many interrelated aspects of science. Such is the case in the widely discussed program of soil conservation or efforts to prevent the possibility of disastrous results from floods.

Quite naturally in the course of this discussion the question arises whether the knowledge which we apply in conservation or in industries, or in various aspects of advanced phases of business is in itself an extensible thing. May it be that this resource can be greatly and effectively enlarged? This is a point at which research becomes important. For it is itself an effort to advance knowledge in all its phases by intensive study and better organization, and ultimately through consideration of better means for application.

Development of New Knowledge

I remember well in war time a group of leading American scientific men in Washington discussing often the future of this and other countries, recognizing as they did the ultimate blighting effects of the world war. The comment which they made most frequently was to the effect that the future of America depends more largely upon the development of new knowledge, and its better organization, than upon conservation of resources as that activity had been understood commonly.

Having spent a considerable part of my life in advancing studies on the history of life, I have been thoroughly saturated with the idea that evolution, or the principle of continuing growth and development, constitutes one of the most important truths obtained from all knowledge. I look upon the idea that life through past

ages has continued to develop as presenting to us the hope that such development and opportunity may continue. And at this particular stage in the history of the world, when we see the resources upon which we have depended in our own country quite distinctly blocked out or appropriated, it is important to realize that the greatest possibilities for future growth seem quite definitely to lie in that development of new knowledge which we commonly characterize as research.

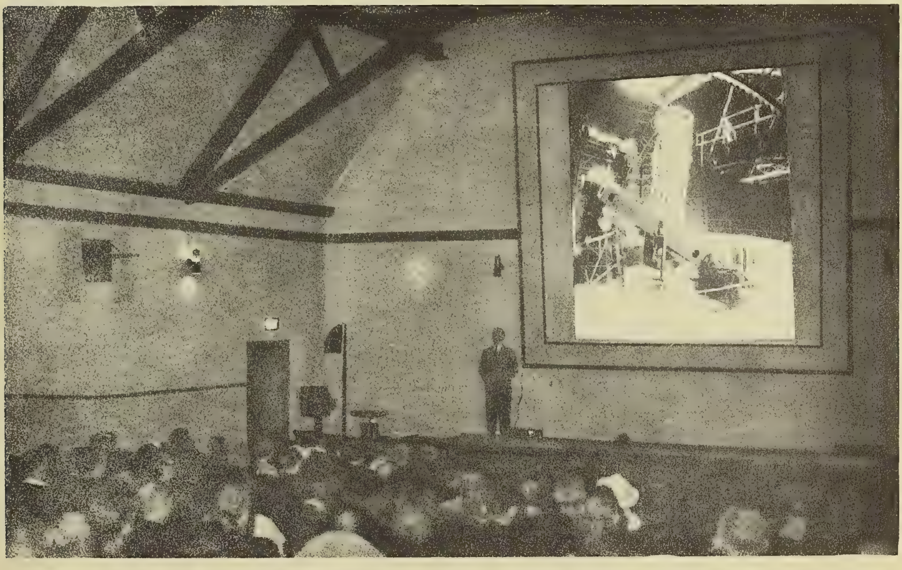
Creative Activity Through Research

I find further interesting elements in this view of research, as it means in some measure the shifting of responsibility for the future of resources in general to man himself. Endowed as we are with intelligence, we have opportunity to bring into play creative activities made possible by the combination of characteristics which the evolutionary process has given to man. And I believe that, other things equal, we would prefer to have opportunity for developing this creative activity through research in the advancement or evolution of mankind, rather than merely to be carried along by the current, without having some part in the betterment of our situation.

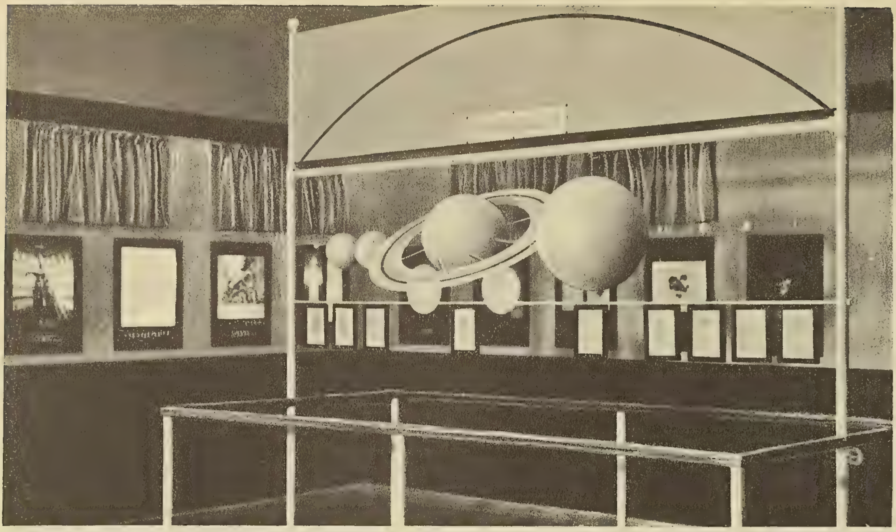
Some of my friends believe that, while mankind has initiative and creative ability, he may lack the capacity for restraint which is needed in use of these great powers, and that he may break under the strain of this effort. Such a point of view seems to have maintained itself through the ages. Perhaps we see it in the story of man in the Garden of Eden, who ate the forbidden fruit from the Tree of Knowledge and was put out of the garden. Man was said to be driven from the garden lest he learn too much. It would seem that he was banished in order that he might become master of himself. From what we learn in history it would appear that the experience of mankind might well teach him the value of his strength, and that he may be trusted with the use of his initiative and creative ability.

Concerning the possibility that research is a luxury or a plaything, one must admit that even things of value are sometimes used as playthings and function as luxuries. But I am inclined to look seriously upon the possibilities of research, and to consider it one of the elements indispensable to present and future civilization.

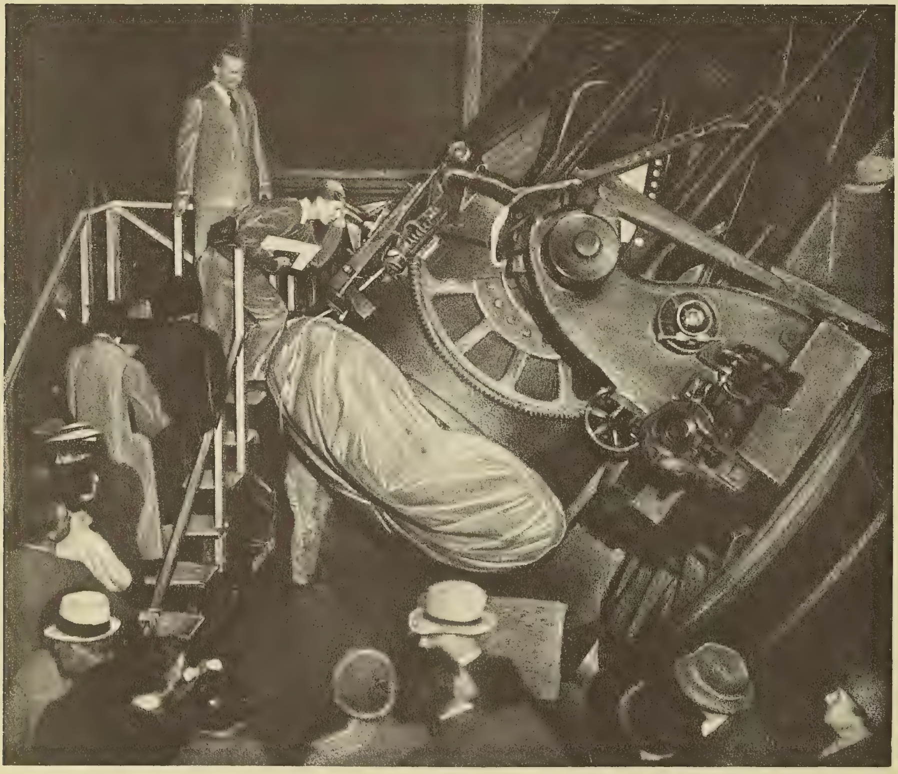
View of the auditorium and exhibits building, erected in response to effort by Carnegie Institution to interpret the results obtained in its investigations. The building is designed for illustrated lectures and to house a permanent exhibit. It is located on the summit of Mount Wilson, within a short walk of the 60-inch telescope which is reserved one evening each week for use in demonstrating to visitors how astronomers employ such instruments.



The auditorium, seating 272, taken during the regular weekly lecture. For many years it has been the custom for one of the members of the Observatory staff to give a general lecture every Friday evening preceding the demonstration at the 60-inch telescope.



Models in the exhibit room showing relative size of the sun and planets. Reading from left to right—Pluto, Neptune, Uranus, Saturn with its rings, Jupiter, Mars, Earth, Venus, Mercury. The size of the sun on the same scale is indicated by the incomplete circle on the framework above the models.



Visitors at the 60-inch telescope on a regular Friday evening demonstration. During 1936 about 10,000 persons used this telescope for observation on the weekly nights when it was placed at their disposal. It is much better adapted for such general use than the 100-inch.

Contribution of Research

Concerning the question, "Why interpret research?" one may reply that activities of this nature contribute in large degree to advance of several types of human activities which are clearly fundamental in any classification. First of all, research contributes in a vast number of ways to practically all human activities in industry, business, agriculture, and in other directions which have to do with the *making of a living* or the *maintenance of life* through the furnishing of food, raiment, and all those things which go to maintaining a balance in living.

As a second point of importance, research contributes in very large measure to those opportunities for advance in the activities of the world which are made possible through the introduction of new ideas and new materials. This phase of human life perhaps seems less important than the maintenance of life, but from other angles of vision it may seem that life is doubtfully worth living if it does not offer opportunity for *growth*, *development*, *advance*, *progress*. And to this phase of living the contribution of research is large.

In still another point of view science contributes very largely to the *building of basic philosophies and beliefs* which invariably function in the picturing of relations between various types of facts and different aspects of organized knowledge. This broad vision of the world, with what is in it, is characteristic of the highest aspects of science and research.

And, finally, research and its forms of expression in science furnish much of importance in securing such an understanding of the world as is essential in our efforts to derive *enjoyment from appreciation* of the multitudes of things about us.

Interpreting Research Results

Now the connection between the intensive study of the world and what is in it by way of research and the various types of influence to which I have just referred as flowing out of research is one which appears important once it is explained. But the explanation of these relations does not arise immediately from the complicated formulæ which are the shorthand forms of expression needed in the work of the scientist. It therefore becomes important that the various classes of people who from different points of view see the

values of research in maintaining and developing life, in the philosophies of life, or in the modes of appreciation of life, should have opportunity to know what the realities of science actually are, and to know the type of picture which these realities present in terms of human interest. If science and research are to help in development of civilization, it is important that the world have means of visualizing the materials which research discovers or creates.

Interpretation of research results will naturally and properly be developed in a multitude of ways. Some will be purely *descriptive*. Some will bring about personal *contact with great realities*. And some will *present realities in action*.

The press, as represented by the daily papers, magazines, special articles and books, must be expected to transmit what may be called a picture of research as it advances. Great progress has been made in every aspect of this activity, and the daily papers carry an amount of information in excellent form which would in past decades have seemed out of the question. Magazine articles and books in great number give us both characterization of specific things and discussion of generalizations regarding the results of investigation. But we are today more than ever greatly concerned about the enormous difficulty of presenting an accurate, scientific, artistic, philosophic, and humanly intelligible description of advances in science and research.

In the course of history but few men have had the ability, first to see and second to picture with true artistic value what is encountered. The reporter who merely attempts to select and mention what the essential elements are in a great scientific discovery finds himself faced with difficulty in determining what is basic, and, furthermore, in developing the talent required for presentation of a picture which will be human literature of a high type.

There is needed today, perhaps as much as in any other field touching science, the appearance of those who know accurately and who can picture what is seen in an effective way. This is a responsibility of the scientist as well as of the reporter.

The Museum, a Means of Interpretation

In presentation of great realities we find the museum in various types of institutions, and especially those arising out of the industries, making available to the public actualities, either static or in

action, producing an imprint as important as any mere description can ever be. The educational institutions naturally use these means of presentation in extremely effective ways.

Question arises as to the responsibility of research institutions which are set up for the purpose of advancing knowledge, to interpret that which they discover. Or, shall we assume that the results of great scientific discoveries are to be interpreted only by those who have obtained their knowledge second hand?

Presumably both methods will be used, but it would seem unfortunate if those who *know best* and who *see most clearly* and who *feel most deeply* the real scientific discoveries do not help in various ways to make the deep imprint upon human thinking which should naturally come from their interpretation.

A research agency such as the Carnegie Institution of Washington is continually in contact with great realities which have been almost entirely hidden from the eyes of the public, and even from deeply interested scientists in other fields. The question had arisen with us whether it is not a responsibility to try to present in some measure an opportunity for contact both with the exceptional realities which we are privileged to see, and with the great ideas which naturally flow from study of these subjects.

It is not, of course, possible to make available to every interested person all of the deeper wonders, but it may be feasible to show enough to give some appreciation of what the field of research means. It may also be possible to give opportunity for inspection of the kind of mechanisms used in securing the data constituting the results of research.

The Auditorium and Exhibits Building

The building in which we are situated this evening is one door by which an interested public may pass to a large telescope such as the 60-inch, to view, as it were eye-to-eye, some of the great features of the heavens; or to make acquaintance with the operation of machinery of a type not easily appreciated without opportunity to see it in reality.

What is done here is also the opening of a further door, through the exhibit room, upon the descriptive and pictorial materials which arise from this institution and spread widely through the press information as to the discoveries being made. Although this event

means the framing of only a few windows opening out upon the little known, it is hoped that by this method there may be increased in some measure the opportunity for appreciation of results of research in this particular field, as they bear upon the many ways of application or use of astronomical research touching human life and interest.

And so: by authority of the Trustees of Carnegie Institution of Washington I here announce officially the dedication of this building, its equipment, and the program of use that it represents, to service of the public. May it help to make clear some of the results of investigation and discovery in the greater universe about us.

REMARKS ON THE PLACE OF EDUCATION IN A RESEARCH INSTITUTION

In the intellectual world question is often raised as to advisability of setting up an organization of the type of this Institution. This problem involves the significance of all institutions devoted to research alone. I have many friends who believe that special research organizations do not justify their existence; that research should be directed by the greater educational institutions. I meet this idea everywhere. I have encountered it in several board meetings within the last month. It is never absent from my mind, and, as our work proceeds, I must constantly inquire whether such an institution as this seems fully to justify itself.

Another problem that has been before us in the field of science as much as any other in the last twenty-five years, is the inquiry regarding the place of research in educational institutions. I believe this is now settled. It has been determined that the educational agency has, first, the task of handing knowledge over to others, but that the mere standing in line and passing bricks along may after a time become a task of such a nature that the brick passers cease to know what is being done. It is important that educators be acquainted with the knowledge they pass on, not merely by hearsay, but from actual contact with it.

Education today is largely devoted to training of youth; in the future it will give increasing emphasis to continuing intellectual growth of adults. By reason of the fact that those being educated are young, it will be some time before they come to make large use of what is given them. When they reach the stage of utilization of this knowledge, its application will have changed in some measure. Therefore the best education consists in teaching the way in which to adjust or to grow on the basis of fundamental truths.

So the universities have included the idea of constructive thought as a part of their program. But when you turn an educational

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institution toward such work there is danger that it may become largely a center for discovery or advancement of knowledge, rather than for character-building and training in the use of knowledge.

In addition to recognition of constructive thought, or research, as a normal part of their field of activity, educational institutions recognize the importance of training in application of knowledge. Especially is this true in such fields as engineering, where the educational course tends to bring into brief limits of time an experience commonly representing many years. By this means we make short cuts in individual lives, and lead the students directly to the programs in which they will later be engaged.

If you step now to another field, that is to the great industries, it is interesting to find that the activities represented there have gone far beyond mere application of knowledge, and now reach into the field of investigation. Today, as everyone knows, the industries are among the greatest promoters of research. But beyond this, we find that they are also performing a tremendously important educational work.

When industries began to advertise they saw that advertisement which was not honest did not pay. Honest advertising reacted to affect the nature of the product. Then it appeared that in order to have a good market the people should know the full truth about the good thing advertised. In this sense advertising changed from mere promotion, regardless of the value of the product, to education of the public concerning good products and their use. The industries also found that knowledge regarding their researches gave confidence in their program and product. The promotion of this idea became a process of true education of the people in research. So, almost before one could realize it, the industries became educational agencies. They now conduct educational work of great significance, not only in the commonly accepted meaning of this term, but in their influence upon thought as well. We are even attaining a stage at which we appreciate the danger to the public from commercial advertising and promotion that has as its purpose the mere selling of commodities not needed, or which are unloaded because of desire to sell without reference to good of the community. There may come a day when wasting of good material in a manner disadvantageous to the public will be considered a crime against the community.

Education by the industries is not the education of the young alone, in the sense in which this is true in educational institutions. It is mainly education of the great group of adults.

In looking over the history of education, one can begin with the Church. It has been in part an educational agency, but never devoted in any large measure to research. Whenever it concerns itself with research it holds its place more easily. Then came institutions specially organized for education—schools, colleges, universities. They included research as a necessary part of the program. Then industrial agencies became research centers and are now in the field of education.

Seeing how these other agencies have recognized the need of relation between research and their major activities, should we not in turn inquire whether there is a connection between the specific subjects which they represent and the dominant idea of research in an organization like Carnegie Institution? I do not believe that a research agency such as ours can make its work fully effective unless it comes to full understanding of its responsibilities in other directions. This does not mean that I have in any sense the idea that this Institution should deviate from the path upon which it started. It should be devoted to fundamental research. But I question whether even the most fundamental investigation can reach its highest point of effectiveness year after year, decade after decade, unless the members of the staff have some form of educational contact, and have a knowledge of the meaning of what is being done in the sense of human service.

When I use the term "sense of service" I do not mean that when, for example, the Geophysical Laboratory discovers something that could be applied in engineering, it should immediately find a means of engineering application. But I do believe it important to be actuated by the spirit of service, and that our Institution should be so organized that all data of value can find easily the place where they will be of largest use to humanity.

It is extremely important that we initiate recognition of this educational influence within the department, so that members of the staff will educate themselves by contact with others in their own group, as with members of other divisions of the Institution, and of other agencies.

There have been organized bodies of investigators in this Insti-

tution in which the groups were not merely in large measure isolated from the rest of the world, but the members were separated from each other. They did not come together as a group to discuss their own problems. I question whether any body of researchers can proceed effectively and understandingly in its work without the elements of mutual understanding and support among its members. It is essential that the group keep informed as to the general problem toward solution of which it aims, and that there be abundant opportunity for discussion of work under way. Conferences of an informal character offer one of the best means known for keeping the whole body educated, unified, and in best possible position to support the general program.

The next aspect of educational work within the Institution to be mentioned is that in which we consider interrelation of the departmental groups. This relation is being emphasized in the course of the present annual meeting. The exhibit of current work set up here today is not solely for the purpose of allowing us to see it. One of the first objects of the exhibit is the bringing together of members from different departments. It has been a splendid experience to me. I think it has been to them, and I hope it will be also to you.

The present relation of our departments to each other is furnishing a stimulus of real importance. Yesterday morning there was held in this room the first meeting of the Moon Committee, a group of geologists, astronomers, physicists and mathematicians set up by the Executive Committee to study physical characters of the moon. I presume that this research is as far from the practical as anything could seem to be. The purpose of the study is not simply to learn about the moon. It is to inquire regarding certain problems touching geologic activities on the earth, which we can perhaps come to understand best by the comparison with conditions on the moon, because the physical relations there are different from those on the earth. We are so accustomed to seeing things under specific conditions that we cannot easily visualize them as otherwise controlled.

Dr. Wright tells me that they have just been working on one peculiar aspect of the moon problem, that is the "streamers" around the craters. No one understands what these objects are. Dr. Wright stated that they might be due to explosions on the moon.

He calculated what the pull of gravity is on the moon, and how far material thrown from a moon crater would travel. It was calculated that a projectile fired from a certain gun on the earth would travel about 8 miles. On the moon the same gun and ammunition would send a projectile about 280 miles. In this way, an explanation was reached of why the streamers around the moon craters extend such long distances.

May I remind you that this moon conference was a meeting of astronomers looking out from the earth, and of geophysicists concerned with the interior of the earth, and they all obtained a new point of view. We have shown here the importance of bringing together groups with certain common interests, but with different points of view. I have commonly called this focusing of vision from widely separated fields the "parallax method." It is the viewing of a particular thing from the points furthest apart from which observations can be made.

When astronomers wished to learn something about the dimensions of the universe they accomplished little until observations of the stars were made from opposite points on the path of the earth around the sun, the two observation points being separated by a base line of something like 180 million miles. They were just barely able to make certain of a perceptible angle between the lines of sight separated by this distance. But the instant they were sure of that angle, with a base line of 180 million miles, there flashed into being a universe with dimensions never before fathomed, and there were opened the tremendous depths of space that we know today.

And so we can apply this parallax method in study of our general problems. This is one of the ideas which I have in mind regarding mutual support of the departments of the Institution through relationships by way of viewpoints which may be far apart, but will in many instances give a new picture of some important phase of the universe.

Beyond the problem of education within the Institution, it is a duty of departments and members to make contacts outside through reports by which the material we produce can be made available to other agencies, through the general literature, or by the usual channels of educational work. We can spend a small portion of our funds profitably in developing new relationships in

order that our results of research may be made useful as easily and quickly as possible.

A view of research such as has been discussed awakens in the minds of those who are doing the work a clearer realization of its value to the community, and a sense of responsibility to the staff, to the departments, to the Institution, and to the public. This view of our relation to the world is of enormous significance in keeping the best kind of continuing stimulus for our program. Many problems in the Institution have directed my attention to the importance of this feeling of responsibility. I have come to see that some of the greatest possibilities of isolation and consequent loss of effectiveness in research may arise from lack of understanding of this relationship. Isolation or failure to realize responsibility may not be due merely to lack of administrative control. It may arise through absence of that stimulus which comes from contact with ideas and opinions of co-workers.

In general our highest accomplishment in the investment of money in research is in groups organized so as to give such relationships within the department, the Institution, and the field of research represented, as will enable the investigator to have a perspective in his subject and the support of other workers related to his field of study.

The understanding of ideas of others and the check of interest may be more important than mere supervision, provided individual initiative is maintained, and the work is well organized and directed, and the true relation to the community is understood.

When we all come to see the various aspects of our problem, and come to full realization of our responsibility to the public, we shall have reached a situation in which we will see our duty, first, as an agency dedicated to active work in securing knowledge regarding fundamental problems, and, second, as an institution responsible to the whole people for giving them in the most available form the knowledge that arises from our results. When that stage is reached we will have the highest form of supervision, such as is realized in recognition of responsibility to ourselves and to others.

I cannot conclude without making one other reference to our problem. It concerns the ultimate significance of the whole research movement in the fundamental sciences. I have stated to you often that the longer I live, and the more I see of the processes

of evolution and its history, the more I am impressed with their importance. Nothing in the world seems to me more significant than this question.

Some years ago Dr. Welch persuaded me to talk before a group of gentlemen in Baltimore. At dinner he asked me how I justified my abandoning palaeontology to go into administration of research. I replied that this was easily explained.—Palaeontology presents evidence of movement of life during the ages, gives us evidence that life is a thing which in this environment cannot stand still, and suggests that if this has been the mode of procedure for a thousand million years it will probably be true for the immediate future, whether we wish it or not. Research is the means by which man will assist in his own further evolution.

Then I stated that science recognizes man as having come to his advanced stage in this scheme after long ages required for his development. Man now sees his situation in the universe as a product of evolution. He has attained intelligence and recognizes his position of individual separateness.—Some of my friends think that through reaching this stage man begins his own destruction,—just as in the early chapters of the Great Book there is an account of man being turned out of the Garden of Eden, because he ate of forbidden fruit from the tree of Knowledge.

I believe that human kind has come to know enough not only to recognize that which is evil that it might do, but to appreciate also the good, and to know the difference between good and bad, and how to select the good. I see, further, that by reason of his intelligence man has come to be a very individualistic type. He insists on something different from what every other creature has. This will be true so long as he is intelligent. But man has also learned that he is in a world that brought him up to a certain stage by a process which we call evolution. He will wish to have some part in this movement. I believe that if he had open to him a choice between further evolution directed by some Being distant from us, which would merely carry him along with the current; or as alternative could choose a situation in which that outside power would fix the laws and permit him to use them, man would say "I prefer to assume some responsibility in this scheme."

I believe that research is the means by which man will participate in carrying the process of evolution forward, learning a little at a

time. In this way he will not obtain too much knowledge to make participation dangerous. He is not to destroy himself, but will make his position better. He will be happy through recognition that, though there are ills with which he must contend, it was in this environment that he grew to his present man's estate.

According to the ancient story, man was driven from the Garden of Eden lest he might learn too much; he was banished so that he might become master of himself. A flaming sword was placed at the east gate, and he was ordered to work, to till the ground, until he could come to know the value of his strength. He is now learning to plough the fields about him, shaping his life in accordance with the laws of nature. In some distant age a book may be written in which it will be stated that man came at last to a stage where he returned to the Garden, and at the east gate seized the flaming sword, the sword that symbolized control, to carry it as a torch guiding him to the tree of life.

REMARKS OF THE PRESIDENT OF THE CARNEGIE INSTITUTION OF WASHINGTON BEFORE THE BOARD OF TRUSTEES

Mr. Chairman and Members of the Board: Each year I approach the presentation of a report with hesitation greater than in previous meetings, because I realize that it is impossible to make an adequate statement of progress in more than the most general terms. Each time I have called attention to the fact that the real report on activities of the Institution comes to you in the Year Book, and in the various documents reaching each member of the Board soon after their publication. Copies of the Year Book, which is released as of today, are here on the table for members who wish them. They are forwarded to you a little later without reference to request made today.

The Institution's Year Book

For 1935 we have attempted to modify the Year Book in several particulars so as to make it a little more useful to the Trustees. I recall that some time ago this volume was growing thicker and thicker, and we decided that a limit must be set. I remember that Mr. Root called attention to the fact that in about another two years it would be two volumes, and he considered one volume enough; and so did I.

The Institution committee known as "Committee on Public Progress Reports"—which name, you remember, was constructed by Mr. Root—has made it an especial task for a number of years to see that the reports on our scientific projects are held down to such limits as will permit putting the whole statement in one volume. I wish here to compliment that committee on its success. In a considerable number of the departmental reports you will find a summary or a preface with a review of the whole field. I have been so impressed by the way in which these statements are presented

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that, in writing the President's Report, quotation is made from some of them, because they give simple outlines covering certain of the most important elements in department programs.

We have had great difficulty in determining what objectives should govern in preparing our reports. There is wide range of opinion as to what the Year Books really are. Some members of the Institution staff consider that they provide a means by which small scientific papers on special projects can be issued. So there has been a tendency for the report to become a collection of important technical papers. But the question is: Are such technical papers the things that we wish?

Other members believe that the Year Book is, first of all, a statement to the Trustees, and that it should be intelligible to all thinking people; they feel that it should be possible to read it through with appreciation of the meaning.

We have not yet arrived at a full understanding of the problem, and in the 1934 report you will find some statements that are technical. In defense of those who wish to see here a collection of technical papers, I should say that all of the departments obtain copies of their reports; and these reprints are circulated among scientific groups, especially those interested in the same field, so that the material in the Year Book reaches a very large number of investigators scattered over the world. The attempt now is to combine these two types of statements so that, for example, in the report from Genetics or from Mount Wilson or from the Division of Plant Biology, you have in each case a preliminary statement two or three pages in length plus a more technical review of progress made by the department in the whole field.

We have attempted this year to divide the material in the Year Book report into administrative and scientific sections. The first portion includes reports of the committees, the Executive Committee and the Finance Committee, the schedule of securities, and the auditor's report. These are followed by the President's Report, which is a summary of the activities of the Institution. This year, instead of picking out single items from the whole group of projects, I discussed progress of the Institution by Divisions.

We have introduced one new element in the Year Book, namely, the report from the Division of Publications. Up to the present time the statement on publications has been included in the Presi-

dent's Report. But the subject is so important that we thought it should be covered by the editor; and you will find this review following the scientific reports. At the end of the discussion on publications comes the bibliography of the staff.

Publication Channels

I do not know how the Trustees feel, but some of us spend a good deal of time looking over the bibliography. Not all that we do is expressed in terms of the printed page, but a great deal appears in that form. Here let me call your attention to the fact that when we say "bibliography" we do not have in mind solely what are called the Carnegie Institution publications, of which you see the 665 volumes ranged around this room. The Carnegie Institution publications are merely an outlet by way of monographs for reports of such size or character that they are unsuited for the ordinary channels of publication. They are not considered merely as a monument to the Institution, or to Mr. Carnegie, or to science. They provide means for setting down a technical record, a report upon investigations, which can not easily find place in other ways.

When members of our staff come to us and say, "Would you feel it proper for me to publish a paper in the *American Journal of Science*, or some other important medium," I say, "My dear sir, we are glad to have you place your paper wherever it may accomplish the largest good. Do not think that it should necessarily go into the Carnegie Institution's series." As a matter of fact, the larger part of all that is published, bearing upon our work, passes through other channels. I mentioned the *American Journal of Science*, which happens to be a medium through which our Geophysical Laboratory publishes much of its material. Mount Wilson Observatory has several channels through which the staff publishes, the most important of which are the *Astrophysical Journal* and the *Publications of the Astronomical Society of the Pacific*. Other departments, likewise, use special journals.

Let me remark that we are not attempting to saddle on other agencies the financial responsibility for our publishing activities. The *Astrophysical Journal*, for example, might feel that we are imposing on it if we tried to put too much material through that channel. What we do is this, the papers are offered and accepted as would be the case for articles from other sources. If there is

extra material, or a relatively large number of pages, or illustrations that are expensive, we pay for them. The departments are given funds for meeting expenses of this character.

So I am stating to you, as I have done many other times, that the real report for the Institution, and in a sense the report from the President, is contained in these publications. On the table here are many documents which include everything covering our activities—the minutes of the Executive Committee, the financial report, statement on investments, copies of publications, and a considerable group of copies of the papers from journals such as the *American Journal of Science*.

May I say again that not all that we accomplish is expressed on the printed page. A very great deal of what we do is represented by influences exerted upon institutions and individuals through direct contact by members of the staff. Much now goes out also through the public press, ranging from newspaper releases to articles in magazines, various types of journals, and the publication of books. We have not wished to stress too heavily what some would call the publicity aspect of our work. This is viewed as a part of our public progress report. Mr. Root has impressed upon me very definitely a number of times an idea held by him and by Mr. Carnegie. It is that there should be means by which we not only make technical record of the results of scientific research, but present as well a general statement intelligible to the public and to scientific men in all fields of research.

Program of Interpretation

So some years ago we began to develop a program of interpretation. I have probably said to you before, in reports, that to our surprise the first important result of this effort to put down in simple form the results of our work was in a reaction from the scientific men rather than from the lay public. What I mean is that, for example, the botanists approved definitely of a statement of results in the fields of physics and chemistry, and even what comes from astronomy, etc. We find that science is so specialized that the men in each subject are grateful for an interpretation of what is being done in other fields. This contribution has been important.

We have attempted also, as you all know, to carry out this plan of interpretation by means of a series of lectures. I do not wish to

stress this point, because it is a relatively small thing; but the lectures have come actually to be quite important, and we are arranging to have them presented not only here but at all places where the Institution is represented, as at the Mount Wilson Observatory, Cold Spring Harbor, and other stations where large departments are located.

The lectures are not directed alone to the audience that happens to be present when the statement is made. Nearly all are now published, not only recorded through journals, but brought together in collections or groups of lectures which are included in a supplementary series of the Institution.

The last series of lectures set up consisted of two delivered this month under the title "The Influence of Science and Research on Current Thought." The men who spoke were Dr. Angell of Yale and Dr. Spoehr, Chairman of our Division of Plant Biology. Both statements are of the highest order of excellence. These lectures are being brought together in a small book. As you may know, Mr. Root has given his approval to our use of the name "The Elihu Root Lectures" for this series. I have said that anyone who speaks in the Elihu Root Lectures must at least come up to look out over the level of thought which Mr. Root represents.

Another point regarding these lectures, lest you misunderstand my position in viewing this subject, is that the giving of a lecture does not concern merely the people who are present, or the persons who read the article after it is set down in a magazine or in a book. One of the most important influences is upon the Institution itself. We all know that the mere presentation of such lectures does not mark the end of influence from the effort, because what is prepared continues useful through the whole life of the individual, and is used continuously in dealing with other projects of the Institution. So we have rather deliberately fostered the lecture as being perhaps one-tenth or one one-hundredth of one per cent of the contribution by the Institution.

You may think that I am spending too much time on problems aside from the main objectives of the Institution; but in this connection, I wish to say, last of all, that the exhibits here in this building today represent another mode of expression or report on our work.

It is one thing to engage in an investigation and publish a technical

scientific paper. We have all written articles on various subjects that were technical, whether they were scientific or not; and we know that there is a real difference between standing before a scientific group and talking in terms of hypotheses, and standing before the public to be asked questions concerning the subject. There is also wide difference between discussing a limited field in science and considering that subject in terms of other sciences. After all, science is not just isolated facts. It is facts related to other facts. In other words, science does not become science until this relationship or philosophic aspect is developed.

So one finds that if research workers state their problems, perhaps in terms of mechanism, perhaps in terms of vision, and interpret them to others either through lectures or through exhibitions of actual material, the reaction is helpful in clarifying the thought of the investigator.

Values Derived from Exhibits

Some years ago I think I told you that just before a meeting of the Trustees the Chairman of the Committee on Exhibits said to me, "Well, Dr. Merriam, we are on velvet from this time on. The staff has profited enough in preparing the exhibition to pay for all the effort and money that has gone into it." He said, "We hope the Trustees and public will enjoy it, but if they should never see it at all, it would have been worth while." While we have been talking today, the exhibitors are here in the building, going about together, to see each exhibit, and to ask each exhibitor questions as to what his work means.

It is important to note that the exhibits which you will see are not incidental things gotten up on the spur of the moment. Without my realizing quite what could happen, they have become a part of the life of the Institution.

A very interesting story attaches to one of the most important of the exhibits here. On the other side of the hall you will find three rooms devoted to genetics. The room at the right is an exhibit in charge of Dr. Bridges, long a member of our staff, and an assistant to Dr. T. H. Morgan. As you know, Dr. Morgan has done very important work, perhaps the most important in the world, upon certain aspects of genetics. This research has had its principal support from the Carnegie Institution of Washington.

We have not troubled Dr. Morgan about exhibits and lectures. He favored us with a lecture some years ago, and did it very effectively. Last year, just after the annual meeting, Dr. Morgan wrote to me saying that as a compliment to the Institution he would appreciate showing in the exhibit of 1934 some of the results that have been made possible by aid of the Institution. So Dr. Bridges is here with that exhibit. He brought the materials from California Institute, but it seemed that a good place to work up data would be at Cold Spring Harbor, where the Chairman of the Exhibits Committee of last year was located. Cold Spring Harbor, of course, is our principal stronghold for organized genetical research.

At Cold Spring Harbor is Dr. Demerec, a distinguished student ot genetics who had been the organizer of the exhibit for the International Congress of Geneticists, of which Dr. Morgan was President. There Dr. Demerec did a spectacular piece of work, attracting the attention of geneticists over the world. He had gardens with plants growing, and microscopes to show details. When Dr. Bridges came to Cold Spring Harbor, Dr. Demerec said, "We will put a Cold Spring Harbor exhibition alongside that of Dr. Morgan." Then the Department of Embryology, which has one of our geneticists doing somewhat similar work, said, "We will add another;" so there are three exhibits: Bridges, representing Dr. Morgan; Demerec, representing genetics at Cold Spring Harbor; Metz, representing genetics in the Department of Embryology. The three are together. Perhaps it is the most important exhibit of the sort ever assembled. It represents nearly a year's work.

Last spring we stated that we were not willing that these exhibits proceed unless there be development of plans in such manner as to constitute a research. I am told that they have served in a measure as an investigation. This is the story of one exhibit. I regret in one respect that it will not last long, but that may not be the case. It goes to Pittsburgh, and we are now asked whether it cannot ultimately go to a great museum as a permanent exhibit.

The exhibit in the rotunda, the large cast of a Maya altar from Quirigua in Guatemala, has another interesting story; and it is perhaps well that I tell it. The significance may be greater than that of other matters that seem more formal.

Quirigua has been known over the world as one of the most important of all the Maya ruins. At that place are magnificent stelæ

or monolithic structures with marvelous carvings. Altogether, it is one of the striking and startling exhibits of the Maya area. We have had very close relations to the people of Guatemala; and several years ago I suggested that we would like to see many good people from America visit Guatemala to make acquaintance with its wonders. I was born and brought up in the Middle West, and had in mind the great group of school teachers of that region who save a little money to go here or there, perhaps to Europe, for cultural experience. It is only a little distance to New Orleans, and two nights and a day to Guatemala. There one enters a new world geographically, climatically, biologically and culturally. There we can learn the story of an ancient civilization; and find opportunity for education such as shocks us into attention to many new things. For the use of such visitors this Institution agreed to write a guide book describing the ruins of Quirigua. The book is now ready for publication.

The Society of Geography and History of Guatemala was interested in the book, and it will be published under auspices of that Society and dedicated to the people of Guatemala. Carnegie Institution will pay for the publication. There will be an English and a Spanish text.

We arranged last year to coöperate with Guatemala in making Quirigua as interesting as possible. The Carnegie Corporation combined with us to make money available. The fallen stelæ are now set up and the ruins repaired so far as feasible. When our American visitors come, aided by the guide book, they will see everything in the best possible form. We asked two of our best men, Morris and Strómsvik, to do the work. One of our Trustees, Governor Forbes, visited the locality when they were beginning the task.

In course of this excavation at Quirigua two magnificant altars were found in front of two great figures, called zoömorphs, and about a foot and a half below the surface, where tourists and scientists had been walking over the ground for decades. These are two of the most extraordinary Maya relics known. The carving represents the highest level of work of that civilization. The exhibit in the rotunda of this building is a cast of the better of these two altars. As you will see, the front is covered with hieroglyphs. The mould

of this altar was made in course of the work at Quirigua, the plaster cast was made at Boulder, Colorado, and shipped here. This is a very striking thing; but the point I wish to leave with you last is that it represents not merely advancement of knowledge concerning a great culture. It represents also development of our relations with the people of Guatemala desiring our coöperation, but having themselves a fine independence of thought.

Some years ago I was asked to speak before the Rotary Club of Guatemala City. I do not often speak before Rotary Clubs in the United States, and naturally wondered what would be the point of view of a Rotary Club of Guatemala City. I have never stood before a group of men with more intelligence and vision. Fortunately, practically everyone understood English. I was permitted to talk on the significance of history, and they knew the meaning of this subject, which is, I fear, little appreciated over the civilized world. I think it important that these relations, and discussion of such problems, be given careful thought as among our opportunities for service.

Discussion of relations to Guatemala suggests reference to comparable opportunity in the neighboring country to the south. The Government of Honduras has recently asked our aid. The Ruins of Copan, one of the greatest of all ancient sites, need to be cleared, protected, and interpreted. Dr. Morley, of our staff, has written a great volume called "The Inscriptions at Copan." It did not at first seem possible to help. So we asked the Carnegie Corporation to coöperate. Recently the Corporation appropriated $12,000 for us to use, along with our own funds, and the Copan work is about to be initiated.

When I began discussing exhibits, it was for the purpose of bringing to your attention the fact that the statement of these problems is not all publicity. It is in large measure a crystallization of thought and an interpretation of new materials for a wide public which should have opportunity to know something of these things.

I should remind you at this time that after the luncheon, which will be served at about 12.30 or 12.45, we have arranged, as in previous years, for the Trustees to go about and see the exhibits. There will be only a few persons present—75 perhaps—and you will have opportunity to meet the exhibitors and the directors, and talk

with them about their work. You will find some extraordinary things. Every one of the exhibits is a gem; and it is worth more than anything I can say for you to meet the men, see what they are doing, and talk with them about their special interests. You will find Dr. Spoehr here with a critical exhibit on photosynthesis or the influence of light on plants; Dr. Adams with the parallax or distance of the stars; Terrestrial Magnetism with an extraordinary exhibit on the daily variation of the compass. These researches, and the exhibits illustrating them, have all been worked out with great care.

The Institution Visualized as an Ideal

If you were to ask me questions, I assume that one of your inquiries would naturally concern my view as to the specific task of the President of this Institution and how I look upon our organization and its development. Of course I am asking myself these questions continuously, and try to be prepared to answer.

One of the basic questions regarding the Institution which can never be avoided is the thing which bore so heavily upon Dr. Woodward in his later years. Those of you who knew him well remember that he was deeply hurt by the feeling that a majority of people considered the Carnegie Institution merely as a check-book; that it was just a source of funds for those who might wish to conduct research. However, Dr. Woodward knew that Mr. Carnegie and Mr. Root and Dr. Pritchett and those who organized the Institution, and the Trustees who have carried it on, looked upon this institution as the development of an ideal, and that the ideal relating to advancement of knowledge and its interpretation was the primary feature. We have to keep in mind continuously that we are not merely disbursing funds, but are holding to an idea, and maintaining an organization such as will permit the most effective use of our resources in advancement and clear statement of knowledge.

There has been the feeling, I know, that our first responsibility is to find men. Mr. Carnegie expressed that idea. And all have recognized its importance as coupled with other opportunities. It is my view that we must first have an ideal, and then there must develop a mechanism; but that the plan and the mechanism will be without value unless we have adequate personnel.

An Evolving Organization

A short time ago I came upon a statement by Bacon that impressed me as representing in some measure the situation in this Institution. Bacon said:

> I take it those things are to be held possible which may be done by some person, though not by every one; and which may be done by many, though not by any one; and which may be done in a succession of ages, though not within the hourglass of one man's life; . . .

That outline illustrates almost exactly the evolution of this Institution. There are those things "which may be done by some person, though not by every one." So we have selected individuals who are the source of ideas, and of stimulus. Morgan in genetics, for example, is a man who represented an individual idea carried out and extended over a wide field.

Then, we have the gradual evolution of the departmental type of activity exemplified in Mount Wilson Observatory, the Geophysical Laboratory, and Embryology. The departmental idea was based upon the proposal that certain investigations be entered upon which could be carried through only with many people working together, each having his special interest, but combining in assistance to each other. The Geophysical Laboratory is a good illustration of this type of effort.

G. K. Gilbert, the great geologist, in talking to me before I knew anything of the Carnegie Institution, referred to the field of operations of the Geophysical Laboratory as representing the dark continent of science, the interior of the earth. He said, "Merriam, you cannot see that region, and you never will. You can see the stars and do various things which increase our knowledge of them. You can explore other continents; but the interior of the earth, something that is essential to us, you cannot reach. If there were not an interior of the earth there would not be a surface, and there would not be life, and there would not be people." He said, "It is the most difficult place to reach, and the means of fathoming it are few. How can we ever learn much about it? And yet how can we ever understand man's position in the universe unless we know something about the bulk of the earth upon which he lives?"

You have often heard me speak of the fact that earthquake waves, passing through the mass of the earth, have given to geo-

physics a means of learning something about the structure and composition and nature of the inner earth. Development of the Geophysical Laboratory required information from many directions, and brought group research. There is some criticism of the Institution, I know, on the part of those who feel that we attempt to organize and direct; that the members of these various staffs are under close control of the directors. But no one comes into the Geophysical Laboratory to work unless he is interested in geophysics. The salary is not enough to attract him. He has a living, of course, but men come because they are interested. They do not stay unless they fit themselves to other researchers, and unless they receive from the others what they need. In one sense it is a coöperative organization. In terms of biology it is what we call a symbiosis, that is, somewhat different organisms fitting themselves together to mutual advantage.

The department idea has extended itself to groups of groups. Plant Biology, to which I have referred in the annual report, is one of these larger groups. I well remember sitting here at this table, shortly after I came to the Institution, with representatives of Animal and Plant Biology. There was Dr. Clements, convinced that environment is the great factor that influences life. There was also Dr. Davenport, quite confident that what is in your genes or in your chromosomes determines what you are to be. You may be put into a hot climate or a cold one, but you will be what you were born to be. I have probably told you the same story over and over, and I have said that as we stepped out of the door after that meeting Dr. Blakeslee quoted to me the opening lines of "Thanatopsis,"

> To him who in the love of Nature holds
> Communion with her visible forms, she speaks
> A various language.

They spoke "a various language," and they did not agree. I said, "It is unfortunate that we have in a scientific institution opinions which are as near to being diametrically opposed as this, and apparently not finding a common view point." We finally organized a Division of Plant Biology which brought certain of those groups together. Last summer I saw some of the results of this work, which represents what to me is one of the most important things that has happened since I came into the Institution.

Dr. Spoehr, Chairman of the Division of Plant Biology, is a chemist and a physicist who has interested himself in the influence of light upon the processes of plants, photosynthesis; but he undertook to see carried out the program left by the late Harvey Hall, which concerned the influence of environment in its relation to the influence of hereditary materials.

After Dr. Hall's death Dr. Spoehr said "We must find some means of securing an answer to the question: 'What is the influence of environment? What is its relation to the influence of hereditary materials?' " Fortunately, Hall had assembled a fine group of investigators who are among the leading students in this field. Last summer they organized a symposium on this subject, and brought researchers from the Atlantic Coast and from Europe. These men met in California for a week. The first three days they sat in the laboratory and considered technical questions, and then some time was spent in the field looking over the growing materials.

The conference studied especially what Dr. Campbell will recall as one of the striking plants found at the foot of Mount Hamilton, where his observatory is located. I could drive by the foot of that mountain in the dark, Dr. Campbell, and locate myself by the odor of the particular tarweed growing along the road, that sticky plant which is not good as a bouquet, but has a pungent odor that embeds itself in the memory.

The tarweeds form a large group with many species, and some of those kinds are sharply localized. They grow in this valley but not in that. California has varied topography. It has a very interesting geological history. It has been bumping up and down rapidly through geological time, making new formations, and carving out new valleys, so that there is a marked variety of land forms and also of climate. And the many species of tarweeds are scattered over the State, fitted to the varying topography and climate.

The plant biologists took the tarweeds as the basis of their discussion. They not only studied the distribution of these plants in relation to environment, but Clausen and his group went at the genetical history. "What is the succession of these things in breeding?" They not only did this, but they dissected the plants down to chromosomes and genes, and studied them from that angle. So for the first time, as far as I know, there was brought

together a group of people who took up all the phases of this question and laid all the problems out for discussion. They compared this particular feature with that; and then went into the field and made further comparisons and discussed them as far as they could go.

Not all of the major questions were settled in this conference, but they came as near to obtaining answers as has been possible for any other group. This particular thing could not be done by one man alone. It required a group of people representing the sections of the Division of Plant Biology, and with them leading experts from the world to sit down around the table and argue the problems through.

At the end of the conference the members visited the various natural gardens that have been set aside for study of the flora from the Coast Range of California across the Great Valley, and then up to 9,000 and 11,000 feet in the Sierra, where, at our request, the United States Forest Service has set aside a mountain area, now known as the Harvey Monroe Hall Natural Area, for study and experimentation.

We will not forget that we were talking about organization within the Institution when this story regarding the conference in California began. I was considering the relation between organization and the development of projects, and was making the point that our larger groups represent an effort to set up organization which will make possible studies requiring the collaboration of many persons interested in a common problem.

Said Bacon, there are certain things "which may be done by many, though not by any one; and which may be done in a succession of ages, though not within the hourglass of one man's life." Our development has extended over three decades, and as the mechanism is set up now it may go on effectively for many years.

Unity in Staff Activities

We have been attempting so to develop organization of this Institution that there will be in it a certain unity; not to the exclusion of other units or other people; but a unity, and a recognition on the part of the Institution that if the members of the staff hold together, they obtain more from their work than if acting wholly independently.

The exhibit which you have seen in the rotunda this morning is one means of bringing the staff and the departments together. A considerable number of the staff members now in Washington were at my house at dinner last evening. Formerly we planned various features to entertain the staff at these dinners, but soon discovered that this was unnecessary. Yesterday as soon as dinner was over a group of five men went to one corner, and another group to another place. This discussion in groups is going on and it will continue for the next four or five days. It is important as an opportunity for the consideration of common problems. These contacts have brought about intensive study of certain major questions that could not be handled in any other way.

This leads me to the point of stating that in development of our organization the Executive Committee, at a recent meeting, set up another division, covering the field of Animal Biology. As I said when this Division was recommended, we had unwittingly tried out the Division project before making it a matter of business arrangement. We did not set out deliberately to establish a division. Seeing what other groups had accomplished, we recommended that four or five groups in the field of animal biology meet regularly at the different departments to study problems of common interest. This was done for about three years to great advantage. Within this time there came out of the conferences some things that I had dreamed of seeing done, but did not think would be accomplished in my life-time. The conferences were so successful that it seemed wise to organize the group as a division.

Relations between Divisions

The stages described represent development of certain phases in our organization. I do not wish to foreshadow another type of organization, but merely to say that relationships do not end there. The present situation is illustrated in the Institution by the relation of eugenics to various subjects in different divisions of the Institution. Anyone who has heard the word "eugenics" knows that it presents a real problem, as well as one of the most important of all phases of research. How to use the human material of the world to best advantage, and how to care for its development, not merely in the sense of culture but with reference to physical growth and the preventing of large increase in the unfit, is one of our

greatest questions. We may not wish to control mankind, but mankind may ultimately find it desirable to control itself.

We have a eugenics group in the Division of Animal Biology. Dr. Laughlin, of the eugenics staff, has pointed out that the subject has close relations to embryology. We cannot study the story of man without coming up through development of the individual embryologically. One of the closest contacts of eugenics in another direction is with the Division of Historical Research, in which we consider certain aspects of the record of man historically.

The Division of Historical Research, in its study of the Maya, has shown that obtaining the story of this people involves a great number of elements including some of those within the field of eugenics. The study of the Maya must comprise geology, which means water supply and building stone; the plants and animals, which mean food and clothing; and also in some ways that biological background which represents elements involved in the physical stock and race development of these people. We must give attention also to the study of sociology and related subjects.

Some of you will have seen one of our recent publications called "Chan Kom, a Maya Village," which is the first of three studies on different types of Maya villages. The town of Chan Kom, off the main line of travel, happened to represent an intermediate stage of culture. It was an independent community, but had no roads leading in. It was a village illustrating the stage between primitive culture and highly developed civilization. Of the other types of villages to be studied, one will be in the wilderness, and another near the edge of the city of Merida. I mention Chan Kom to show the range of research upon which we are engaged. The work in this field has been carried on by Dr. Redfield, dean of the social science group at the University of Chicago. When Redfield was made dean, the University allowed him to retain his arrangement to be away for a part of the year to work with this Institution in Yucatan on problems concerning social development of the Maya. The large book, on the table next to the wall, is Redfield's Chan Kom report. Mr. Delano will tell you about it. He and I participated in a triumphal entrance into the village, with the inhabitants strewing flowers along the way. We met the people and spent the night there.

This Chan Kom study represents one point of view of a group in

the Institution concerned with Maya history. We are investigating the social organization of these towns because we should know something of the life of the people today if we desire to understand the history of this group recorded in the great ruins. There is danger that we study only the stones that were left from parts of the buildings of the Maya, forgetting that they represent a people still living in the region.

One of the most interesting recent contributions by Dr. Morley, in charge in Yucatan, has been the tracing back of the history of the Xiu family, still living near Chichen. Morley has followed them to the time of the Conquest, and then on into the pre-discovery or pre-Columbian period. So we have the actual genealogy of a family starting before the Conquest and coming up through many hundred years to the present. The archæologists still continue to investigate the hieroglyphs, but they also study the people represented.

I was discussing the organization of the Institution when reference was first made to eugenics. What I wished to point out was that one of the necessarily close relationships of eugenics in the animal biology group is with activities in the historical group; and that some of the most important work done today by investigators in the eugenics staff of Cold Spring Harbor is carried on through the Historical Research headquarters in Yucatan. Dr. Steggerda, of the Eugenics staff, and his wife have been stationed largely in Yucatan studying the interesting problems of the people there.

This is an illustration of relation between two divisions. The work being done in eugenics is of importance both to biology and to history.

Coöperative Relations with Other Institutions

As one further aspect of development in organization it is desirable to make mention of important relations to other institutions and activities.

As has already been stated, the work done by the Division of Historical Research is in considerable part carried on by specialists from other institutions. The organization plan of that Division includes a small group of highly expert and carefully selected persons who constitute the regular staff. Associated with the

continuing staff is a larger group of specialists from other institutions, such as Redfield, dean of the social science group in Chicago, working with us in Yucatan; Andrade, making studies of language; and many others. A coöperator of still another type would be found in the schoolmaster at the little town of Chan Kom, where Dr. Redfield made the study of village life. This young man, Alfonso Villa, was so much interested in the work that Redfield thought he should be aided to further education, and also that he should assist in the work on Chan Kom. Villa has now spent some time in the United States to secure more advanced education, and gives promise of becoming an exceptional investigator and writer.

It has always been a part of our plan to help in developing the talent in those countries in which we work. This means continuing development of research and protection for the fruits of past labor, whether these results be materials or growth of ideas.

The type of coöperation with other research agencies represented in the Division of Historical Research is illustrated in many comparable ways through other divisions and departments of this Institution.

Considering especially our coöperation with other institutions, I might furnish you a long list of the things that we do for government and for other agencies. I know you will agree with me that this constitutes an important function of the Institution.

The coöperation with other agencies is so important that it absorbs a considerable part of our total effort. Time permits mention of only one case, which is, however, of special interest, this is our coöperation with the Carnegie Corporation. When Mr. Carnegie created the Corporation, he specified that the presidents of the institutions which he had set up should be members. I sit on that board as President of Carnegie Institution. In recent years we have developed an interesting relation to the Corporation, in that we have advised regarding scientific problems presented to that body. There is here tomorrow a meeting of the Committee on Cosmic Ray Research, set up through use of money furnished to us by the Corporation to meet requests from leading investigators. We have also given the cosmic-ray investigators use of our facilities, such as the station at Huancayo in Peru, situated about 11,000 feet up in the Andes. This station has proved a useful in-

strument, because we have there a highly trained personnel at a locality of exceptional importance in cosmic ray research.

The Corporation has also given support to many of our projects, and I am suggesting to you today a resolution of appreciation for such aid from the Corporation. These contributions have helped us greatly in study of a large number of projects. A considerable percentage of these problems are not things that relate directly to our regular constituted activities, but are of such a nature that we can use our mechanism in furthering work which needs support of an operating institution.

Institution Achievements

We have talked thus far about some of our ideals, and concerning modes of organization and procedure. You may quite naturally expect me to say something regarding what we have accomplished. But for the list of things done there is, I believe, wisdom in asking you to examine the Year Book, where the story is told in full. If for no other reason I make the suggestion because the fullness of the report is itself impressive.

If report is made on a large project near completion, there should be mention of progress in the Department of Meridian Astrometry in determination of star positions. This year we have reduced the budget for this work and in the course of the coming year the report will be finished. This will be a case in which we actually complete a major work. A great deal of money, approximately $875,000, has been spent in finding the precise positions of stars, a very important work, but it should be concluded according to the original plan.

Of things beginning, which are of significance, mention may be made of the fact that the Carnegie Corporation has given us $10,000 for a project on high pressure studies at the Geophysical Laboratory, which Dr. Day has wished to carry forward. A few years ago, we advanced the possibility of work on study of conditions that exist in the interior of the earth by remodeling some parts of the Geophysical Laboratory and providing a new heating plant. These changes, collectively, gave further opportunity for research in the high-pressure laboratory.

Yesterday, at the Executive Committee meeting, we discussed a further extended study of certain aspects of the problem of

climate. Everybody here knows that the Carnegie Institution has made what is one of the great contributions to the study of weather through the work of V. Bjerknes, of Norway. Bjerknes' father was a great mathematician, inclined to physics, and Victor Bjerknes is a mathematical physicst concerned with the study of the hydrodynamics of the atmosphere. The grandson is a meteorologist, and it is out of the work of V. Bjerknes that there has come the basis of the modern program of weather study and prediction. We are giving this year a further grant to V. Bjerknes in which, by the way, he is applying his hydrodynamics rather more specifically to meteorological problems. This will be one of the greater contributions in the history of weather research.

Governor Forbes was in my office last year when the grandson of the first Bjerknes called. He said, "My father asked me to present his compliments and to tell you how his work is proceeding. My grandfather," he said, "was a mathematician, and my father is a physicist, and I am a meteorologist."

The next step, with which we are now concerned, is the longer-range study of what might be called climatic variation over the years, and for that we are focusing upon the work of A. E. Douglass on tree-rings, closely related to the work of Dr. Abbot on the variation of radiation from the sun, which, in turn, is related to the work of Mount Wilson on sun-spot variation. We are now setting up a program which will assemble results from the work of Douglass bearing upon study of climatic variation. We are bringing together a group of the most able persons to be found. These include Dr. Bartels from Germany, who is one of the best men in that field, and Dr. S. Chapman, an eminent mathematical physicist of England. Both have worked with us in the Department of Terrestrial Magnetism.

Ultimate Objectives of the Institution

In conclusion may I say that in the Report of the President, already in your hands, attention is called to another important aspect of the contribution from research, one that is increasingly clear as our program advances. This is the idea that in last analysis it is not alone what science does for material benefits, or what it does to modify our environment, that influences civilization and affects life broadly.

In spite of all that is done by the many contributions of science to influence our lives, we have still to ask, "What does this have to do with the developing thought of man and with his attitude toward the world in which he lives?" We cannot forget that the effect of these things may be just what some describe when they criticize science; it might only be getting us deeper and deeper into difficulties; or, if we use it all to best advantage, it may lift us to higher and higher levels.

Knowledge is much more dangerous than fire and water, which are said to be good servants but bad masters. We must set watch to see that knowledge as we acquire it is so utilized as to develop our attitude toward life in such manner as to raise us to a level of bettered appreciation. If possible, it should contribute toward advance in the intellectual and spiritual evolution of mankind.

I see no reason why we should not go on developing, at any rate in fundamental capacity to use the knowledge available. One of the greatest of all things to be considered in study of the work of the Carnegie Institution is, What is the ultimate influence of science, as we express it, upon the thought of mankind and upon our attitude toward life?

I make no criticism of those who feel that religion will save us. I have no criticism of those who think that philosophy will save us. I have much sympathy with my numerous friends who believe that art will save us. It is to be assumed, however, that it will not be any one of these things alone, but rather a combination, and that science will have its part.

Even if in the world of economics and politics we are not able to solve all problems immediately by the scientific method, it will still be true that you cannot advance without understanding, and without the use of facts. One group of these facts may concern development of better understanding of the emotional life. There may be scientists who hold that there is no such thing as significant emotional life; that everything is to be based upon mathematical formulæ. So, with these last remarks as to the types of influence which the Carnegie Institution may have, I will ask you to read the Year Book, and to meet the investigators while they are here ready to discuss their problems with you today.

EXCERPTS FROM THE PRESIDENT'S ANNUAL REPORTS

Researches on New Problems Considered

Carnegie Institution of Washington Year Book No. 20, pp. 9–10, 1921.

Although it may be difficult to define precisely the function of the Institution in general or at any particular moment, it is clearly the duty of this organization to lend its aid, wherever possible, to advance fundamental knowledge in fields which are not normally covered by the efforts of other agencies, or in which other research bodies may find difficulty in initiation of projects. It is evident that as a part of its purpose the Institution must look forward to giving its support in putting into operation researches upon some of these more difficult subjects. We could be helpful in cases of this nature through use of our organization as an initiating mechanism, although the ultimate conduct of the investigations might be under other auspices.

Problems which promise large return for such future investigation are found in the field of seismology or earthquake study and in the general region of human behavior considered in the widest sense and recognized as a problem of strictly biological or physical research rather than as a question of sociology. In the course of the year the Institution has been interested in studies in these fields.

In seismology, an advisory committee has been organized under the chairmanship of Dr. Arthur L. Day, Director of the Geophysical Laboratory. Seven of the leading students of geological science and of physics have accepted membership in the committee and have done much to bring into close and active cooperation the various agencies of the country concerned with earthquake studies. Within the short time in which this committee has been in operation it has gone far to place seismological research in a position to make material advance in our understanding of movements of the earth's crust, and thereby ultimately to contribute much toward maintenance of the security and happiness of people inhabiting earthquake regions.

An investigation into the problems of human behavior, constitut-

ing the second subject to be examined, has been given only brief consideration. It represents one of the most difficult of all researches, but is not second to any other question in the possibilities offered. Without reference to immediate practical use of knowledge of human behavior in control of our affairs, research in this field offers an exceptional opportunity for work on the biological or physical basis of human behavior and on the significance of individual and group differences. In the present status of this question the study concerns mainly the nature of present knowledge and the approaches to research which seem to offer the largest possibilities for securing new points of view or new combinations of effort that may open aspects of the work not previously considered.

Present Problems

Carnegie Institution of Washington Year Book No. 21, pp. 4–5, 1922.

The fact that the Carnegie Institution of Washington is devoted to fundamental investigations is sometimes understood to mean that its problems are therefore identical with those of other investigating organizations. Although this is true in the generic sense, each of the several types of research activities in this country has its peculiar problem. The kinds of work overlap, but each body has an individuality and should have a special function making possible a special contribution. It is this differentiation in purpose that, with full cooperation, makes possible the greatest advances in knowledge.

While it is the part of scientific efficiency to encourage concentration of certain research institutions upon particular questions, it is improbable that we shall ever make the assumption that any one of these has exclusive rights to any special subject. However this type of differentiation may shape itself, it will always be desirable to have among the various research bodies a general difference in attitude toward problems. It is in this aspect of definition or function that we can see most clearly how the Carnegie Institution is to meet its peculiar obligations without destructive competition and without hindrance to other work.

In universities the indispensable element of research must always have such free range as will make it possible for the instructor to keep a vivid interest in the constructive use of knowledge and thus be able to develop this attitude in his students. But universities deal by definition with the whole breadth of knowledge and must

work continuously in all the major groups of subjects. It is there fore inevitable that under normal conditions research support in these institutions will be rather evenly distributed over the whole range of subjects in the curriculum, with relatively small opportunity for stress in any one field. The great and competent government service agencies give themselves with increasing measure to consideration of research problems. Presumably this emphasis will grow as the possibility and need of new knowledge become clearer. In general the activities of this group of departments will naturally be distributed over fields in which there is direct demand for the early solution of problems relating to present needs of the community. The laboratories of industrial organizations have come to be among the most powerful agents in use and in support of research. Their activities are directed toward all regions in which materials may conceivably be found which will make for betterment of the industrial product or for efficiency in its use. The only limits set upon this aspect of research are those imposed by the requirement of fidelity to purposes for which the underlying funds are invested. This permits wide range but at the same time imposes restrictions.

Without multiplying illustrations it may be permissible to compare the situation in our Institution with that of the great research enterprises mentioned. One outstanding feature of our foundation is that it has freedom to distribute its support widely or restrict it to any limits which seem desirable. It may take up researches for which a demand of the community happens to be urgent. It may consider those which are of evident importance but may not be needed in human application for a generation. It may select problems rather than subjects and shift its emphasis from time to time as wisdom seems to warrant. In a word, the characteristic of flexibility with reference to problem, place, time, and method of organization, taken with freedom from the requirement of early application of the result, gives an opportunity somewhat different from that of other agencies. It offers the possibility of exploration into unknown regions which may furnish exceptional treasures. That such freedom of opportunity exists means in reality a responsibility for the doing of what may otherwise be difficult to undertake. It suggests that mere paralleling of other researches and failure to select those lines of activity for which we have exceptional advantages would mean evasion of the duty which our freedom imposes.

These considerations make it clear that with all fidelity to undertakings upon which we have embarked, and with the desire to realize accomplishment for all who are connected with this enterprise, we should continue to make the Institution an instrument for use especially in work upon problems concerning the fundamental aspects of knowledge. We should make certain that our contribution is of service by reason of its intrinsic human value, because it may serve to supplement the work of other bodies devoting themselves to the search for new and useful information, and because it aims to interpret that which is fundamental.

Cooperative Research

Carnegie Institution of Washington Year Book No. 21, pp. 9–12, 1922.

It is interesting to note in the work of the Institution a tendency to reach toward still more complicated and difficult problems through the medium of cooperative plans.

Although the major part of the work of the Institution is conducted through regularly organized departments, it has also been our pleasure to cooperate with a large number of distinguished investigators situated in universities, special research institutions, government laboratories, museums, and industrial agencies scattered widely over the country. No better illustration of our relation to other work can be found than that shown in the long-standing arrangement with Thomas B. Osborne, of the Connecticut Agricultural Experiment Station, and L. B. Mendel, of Yale University. By this plan Dr. Osborne and Dr. Mendel, considering the problems of nutrition from different points of view but acting in closest cooperation, carry on a series of studies on certain agents in nutrition, including the vitamines, which are at the same time enormously important and extremely elusive. These researches are fundamental scientific work in biology and chemistry. At the same time they are of such importance in nutrition and medicine that the future of much that is critical in these subjects will be dependent upon the work now under way in the several laboratories of this country and Europe giving special attention to this field.

An extremely interesting example of cooperative investigation by a department of the Institution and another important agency in a related field is furnished by studies of the structure of matter

undertaken jointly by Mount Wilson Observatory and California Institute of Technology. Investigations in the field of astrophysics carried on with such extraordinary success at Mount Wilson have shown that further advance in astronomical research requires a better understanding of the nature of matter. At the same time it has been clear that the researches in engineering at the California Institute of Technology point constantly toward the need for better understanding of the structure of matter to further advance in engineering knowledge. It has therefore seemed desirable for these two institutions to join forces in this special research and to bring to their assistance a group of the most distinguished men available in the world.

California Institute considers the problem of matter, in its well-equipped physical and chemical laboratories, under the immediate direction of such distinguished investigators as Dr. R. A. Millikan in physics and Dr. A. A. Noyes in chemistry. Mount Wilson Observatory makes use of the sun and stars and observes experiments in progress with the aid of the telescope and the spectroscope. At the same time the laboratories forming a part of the equipment of the Observatory attempt to check, and in a measure reproduce, certain of the effects seen or suggested by study of the sun. Cooperating investigators, such as Professor H. A. Lorentz, of Haarlem, and Professor Paul Epstein, formerly of Leiden, were brought to the California Institute for conference, while Dr. A. A. Michelson, of Chicago, Dr. Henry Norris Russell, of Princeton, the late Dr. J. C. Kapteyn, of Groningen, Dr. C. G. Abbot, of the Smithsonian Institution, and others cooperating with the Observatory have helped to forward this investigation. In order to further the progress of this work the Carnegie Corporation of New York has made an appropriation of $30,000 a year for five years. By means of this grant Dr. Millikan and Dr. Noyes, of California Institute, are made research associates of the Carnegie Institution, thus making possible more rapid advance in this series of cooperative studies.

In the report of 1921 mention was made of the initiation of investigations in seismology or the study of earthquakes. The problem involves study of the nature of movements of the earth's crust and the expression of these movements in earthquakes, which are both geological and physical phenomena. This series of investigations should ultimately give us a knowledge of earthquakes which will

make possible a diminution of their danger by teaching us how it may be met. The study must be approached in such a way as to bring to bear the most advanced views in all the sciences concerned with problems of the earth's crust.

Under the guidance of an able advisory committee consisting of J. A. Anderson, physicist of Mount Wilson Observatory; Ralph Arnold, consulting geologist; W. W. Campbell, Director of Lick Observatory; A. L. Day, Director of Geophysical Laboratory of the Carnegie Institution of Washington; A. C. Lawson, Professor of Geology at the University of California; R. A. Millikan, Director of the Norman Bridge Laboratory of Physics of the California Institute of Technology; Harry Fielding Reid, geologist and physicist of Johns Hopkins University, and Bailey Willis, Professor of Geology at Stanford University, a plan has been worked out for attack on the fundamental questions involved in earthquake study. Marked advance has been made during the past year, and it is most gratifying to report the whole-hearted cooperation of a wide range of the most important agencies in America concerned with the phenomena involved in crustal movements. The United States Geological Survey has undertaken the preparation of detailed maps covering areas of active earthquake movement along the great San Andreas fault or rift in California. The United States Coast and Geodetic Survey has entered upon the work of exact triangulation of certain regions of California which have been affected by earth movements. This survey is conducted with a view to securing detailed information regarding the shift of the earth's crust which has occurred in connection with recent earthquakes. It involves a piece of careful observation such as could be conducted satisfactorily only by an agency like the Coast and Geodetic Survey. The several astronomical observatories of the Pacific Coast are contributing data which will assist in the final determination of questions relating to movements of the earth's crust. Lick Observatory at Mount Hamilton is providing a special instrument for studies in this field. The Hydrographic Office of the Navy Department of the United States is cooperating through arrangement to equip two destroyers with appropriate devices by which they will carry out an elaborate series of soundings along the Pacific Coast. This operation is expected to locate such abrupt changes in the floor of the sea as may indicate the faults or breaks in the earth's crust that have extended from lines

of weakness on land into areas beneath the sea. The Bureau of Standards of the Department of Commerce has made important contribution through assistance of experts whose advice has been needed in the construction of new instruments to be used in the detection of delicate earth tremors in earthquake regions. California Institute of Technology, in cooperation with Mount Wilson Observatory, has given both the services of members of the staff and assistance in construction of instruments. The list of contributing agencies should be extended to include the universities of the Pacific Coast and many other bodies desiring to give their assistance in the effort toward solution of the complicated problem.

Dr. Arthur L. Day, Chairman of the Advisory Committee, has visited personally all of the cooperating agencies and has given close attention to the development of this most interesting program of constructive study. Dr. H. O. Wood, Research Associate in Seismology, has been in charge of the field reconnaissance for the Institution. It is important to note that in this study the interests concerned are not merely cooperating—they are advancing knowledge in each of the subjects involved and at the same time promoting an understanding of the earthquake problem.

Fellowships

Carnegie Institution of Washington Year Book No. 22, p. 12, 1923.

In 1921 a plan was approved for establishment of a small group of fellows in the Institution for the purpose of offering opportunity for association with our staff to a limited number of persons desiring to take up work in the Institution on a temporary basis. This plan was initiated with the understanding that the fellows of the Institution would be persons having exceptional interest in research and adequate preparation for undertaking work on problems relating to our general program. Appointments of fellows have been made in the Departments of Embryology, History, Plant Physiology, and Geophysical Laboratory.

Unique Opportunities of the Institution

Carnegie Institution of Washington Year Book No. 23, pp. 10–11, 1924.

While, in the true meaning of education, the Institution's contributions and contacts may be among the most significant of those

leading to the informing, and therefore the educating, of students in the after-graduation stage, the seeming isolation of this group of workers is sometimes mistaken for aloofness. The organization of our investigations around projects, representing fields of study in which it is especially opportune to have expansion of knowledge, differs from commonly adopted plans in which a general subject such as Greek or zoology is made the area or department in which research is to be conducted.

Added to other peculiar features, the location of departments or investigators wherever their work can be carried on to best advantage has made the group of characters of this Institution still more striking. While many great organizations are to-day giving most careful thought to the suggestion that separation of their departments by the width of a city, or by only a few city blocks, may constitute an obstacle in the way of correlated effort or institutional efficiency, the map of our interests shows important agencies ranging from Boston, through Long Island, District of Columbia, California, South America, and Australia. But it should be remembered that the departments of this Institution have been located generally where they can function to best advantage. The magnetic observatories at Huancayo in Peru and Watheroo in Australia are on opposite sides of the earth because the data from opposite sides are especially desired. After much careful investigation, the site of the astronomical station on Mount Wilson was selected because of its fitness for a special work. Dr. Mayor chose the Dry Tortugas rather than Long Island because he considered it better suited to the purpose of his studies in marine biology.

While the loss due to geographic separation of related interests must be considerable, the possibilities of this plan of operation may be relatively large if close cooperation is established. One of the major opportunities for the future of the Institution lies in just this mutual support between highly developed agencies with exceptionally favorable situation. In such unity there is an opportunity not open in the same way to other kinds of organizations.

Such cooperation has, for example, been found by conference of our investigators to be especially favorable in the field of life development including genetics, experimental evolution, ecology, embryology, nutrition, plant physiology, and marine biology. These departments, groups of investigators, and individual researchers, scattered widely over the country, are conducting some of the best

organized attacks on problems relating to the nature of heredity, the development of the individual, the influence of environment, and other critical questions touching the great problem of growth or development in the life world. Individually these activities make most significant contributions to advancement of knowledge. This opportunity for expression of individual and departmental initiative is enormously important in such a field as research, concerning little-known or imperfectly understood questions and with the avowed object of discovering what is yet outside the boundaries of knowledge. But the fact that there are many points of view and differences in location and environment of the agencies represented makes possible, through the flexible organization of the Institution, a kind of study of these questions which would be much more difficult by other methods of attack. It may be that the way is now open for a much larger realization of result for each and all than has heretofore been within reach. Such advance would necessarily involve also the closest relation to those agencies outside the Institution with which there can be advantageous cooperation.

The peculiarities of the Institution as to purpose, organization, and location open possibilities for ultimate diminishing of its usefulness if it is operated in the same manner as other bodies with somewhat different aims and structure. If we conduct our work on the plans best fitted to our real aims the admitted disadvantages may be in considerable measure overcome, and many apparent handicaps will be found blessings only moderately disguised—Dr. Adams in his work at Mount Wilson found that just because the absolute magnitude of stars is disguised by distance, the discovery of new means for determining the absolute magnitude made it possible to estimate the distance. This gave a method which opened the way for great advances in our knowledge of the universe. So, with careful study of our problem of organization, we will learn ultimately to turn what seems like adversity to advantage.

Financial Provision for Continuing Development

Carnegie Institution of Washington Year Book No. 23, pp. 14–15, 1924.

There can be little doubt that the trend both of expenditure and of opportunity for accomplishment so clearly shown in the history of the Institution indicates in a general way the probabilities for the next generation. Mr. Carnegie had a vision of the need for research

when the Institution was founded. He realized that a period of utilization of great natural resources would be followed by a stage in which intensified investigation of materials, and of methods, would be necessary if the normal progress of civilization be continued. The situation Mr. Carnegie saw is now being realized. It is also clear that the present advance of constructive work is a mere beginning compared with requirements of the future. The opportunity for service by the Institution through contribution in fundamental research will be greatly increased. There is every indication that at the same time we may expect diminishing purchasing power of the resources upon which our work is dependent. If the Institution is to continue serving in a measure corresponding to what it has given heretofore, it is essential that some plan be developed by which its resources can be increased, at least to an extent comparable to the reduction in purchasing power.

By reason of the kind of attack which this organization makes upon research problems, it lacks those means for enlarging income which are available to most agencies concerned with advancement of knowledge. We do not have a rapidly growing body of supporters with the intimate relation expressed in the alumni of educational institutions, nor do we have the possibility of added income arising through modification of tax rate as in government-supported agencies. Unless the Institution allows itself to become dependent for its advance upon continually increasing gifts, a method must be devised by which, through regular addition to endowment, a growing interest return or income can be secured for support of regular operations. Even if considerable funds were obtained by gift, it would be desirable to add a large part if not all of the interest from such sums to endowment and to use for operating expenses only the interest upon such additions.

Without external assistance, a beginning can be made by so organizing our program as to permit adding a moderate amount to endowment each year, thus slowly increasing the income. However difficult it might seem to put such a plan into operation at a time when larger funds could be expended to advantage, it would be better to suffer the temporary discomfort incident to such readjustment, and build for a developing program, than to face the certainty of diminishing effectiveness.

Interdepartmental Cooperation

Carnegie Institution of Washington Year Book No. 24, pp. 13–14, 1925.

Success in the research program of the Institution depends ultimately upon initiative of individuals who derive their greatest pleasure from constructive studies. Our organization reaches its highest level of effectiveness when full advantage is taken of initiative arising in members of the staff concerned with the specific investigations planned. Organization of departments and other groups offers opportunity for combined attack in which each individual profits by united effort of the group. In addition to effectiveness of departmental agencies, it is also being demonstrated that there are large possibilities of progress in united endeavor of departments and other divisions of the Institution initiated for the purpose of solving problems of mutual interest.

In the course of the past year a number of significant investigations have developed within the Institution through cooperation and mutual support of departments or other agencies joining in attack on problems in which there are common objectives, but for which no single group is equipped to handle all researches necessary. Illustration of such combined effort is furnished by a program of the Geophysical Laboratory and the Department of Terrestrial Magnetism, initiated for study of effect of high pressures upon the critical temperatures of magnetization of materials contributing largely to the mass of the earth. This research already gives promise of important results.

This type of research is illustrated in the field of biology by an investigation in which H. M. Hall, engaged in taxonomic and ecological studies, is cooperating with E. B. Babcock, a student of genetics, for investigation of variability in a group of plants, shifted from their normal environment to other conditions, under which they are allowed to grow for a period of several years. Dr. Hall, as a student of taxonomy acquainted with minute variations in external characters, follows from year to year the tendency of these transplants to change their form and superficial characters. Dr. Babcock makes inquiry more especially as to fundamental modifications in cell structure and nature of the hereditary materials. By this combination of studies, understanding is reached regarding extent to which variability, coincident with change of conditions,

indicates fundamental modification of type, and concerning extent to which it is merely temporary response to influence of environment or nutrition without alteration of fundamental nature of the plant.

A further plan for cooperative study to be undertaken in the immediate future is illustrated in appointment of a committee, representing two departments of the Institution with investigators from outside agencies, brought together for the purpose of research on physical features of the surface of the moon. This Committee consists of Dr. Adams and Mr. Pease, of Mount Wilson Observatory; Dr. Day and Dr. Wright, of the Geophysical Laboratory; Dr. John P. Buwalda and Dr. Paul S. Epstein, of California Institute of Technology; and Dr. W. W. Campbell, Director of Lick Observatory. The astronomer will interpret the moon by means developed through long years of careful study of its surface. The physicist and mathematician will approach the problem as experts on physical laws as they are expected to operate. The geologist, volcanologist, geophysicist, and physiographer will interpret the surface of the moon in the light of knowledge acquired from corresponding studies of the earth. Such an investigation, initiated with large accumulation of information available from previous researches, will unquestionably make important contribution to physics, to astronomy, and ultimately to knowledge of physical features of the earth.

Earthquake Study as a World Problem for All Time

Carnegie Institution of Washington Year Book No. 25, pp. 7–9, 1926.

Reports to the Trustees in recent years have contained reference to the program of earthquake research carried on by advice and direction of a committee established and financed by the Carnegie Institution. In 1922, 1923 and 1925 reference was made to the type of organization utilized and to the peculiarly important relationships established with other agencies.

This research is now in operation through various institutions on the Pacific Coast. In the present year it enters a period of intensive study through utilization of new instruments, new stations, and the support of investigational effort from many fields of study concerned with physics of the earth's crust. In approaching this stage of the investigation one is impressed with the magnitude of the task, and with the opportunity offered for contribution to the fundamentals of science and toward meeting a human need of the continuing type.

The greater dangers to mankind are in part of such a nature that we may some time hope to eliminate them completely. Among these are the scourges of disease. It is probably within reach of applied science to discover, combat, and destroy many of the organisms which produce disease. Other sources of danger to life and property, such as storms and earthquakes, we can not control, but through study of their causes and habits we may reach a stage of knowledge at which they will cease to menace our happiness.

Earthquakes are phenomena arising from natural causes in development or evolution of the world. They are one form of expression of movements in the earth's crust which have given us the contrast of land and water areas, and which form the hills and mountains with their great range in topography, climate, and life. There is no doubt that earthquakes have characterized this world for hundreds of millions of years. The physical constitution of the earth indicates that they will continue for at least a similar period. Within historic time they have been the cause of great tragedies, and of much collateral unhappiness. They are a potential source of continuing catastrophes. With increase of population their possibilities of destruction increase. We have no suggestion that man can ever in any sense halt or guide these movements. Research leads us to believe that we can come to understand them fully and thus avoid their dangers.

The function of science in relation to this feature of earth activity is one of long-continued, intensive research, requiring cooperation of outstanding students in the fields of physics, geophysics, geology, and engineering. Application of the knowledge which these investigators secure can be made only by continuing clear understanding of the problem in its most fundamental form, and by education of investigators and of the public through all that future time in which man and civilization shall last.

Although the Carnegie Institution has financed a considerable part of the researches mentioned, the success of the program thus far is due in large measure to cooperation of other organizations, including departments of the Government, universities, and other types of research or educational institutions.

Coincident with development of methods for scientific attack upon the problems of seismology, there has been extraordinary growth of public interest in the work of making the scientific results imme-

diately available for application to save and protect life, and to furnish those guaranties of safety so important for the morale of every people.

At the present moment the situation relating to furtherance of research in this field, and for application of its results for the benefit of mankind, reaches beyond the stage which might have been expected at this time. Advance in development of the technique in seismology, and in recognition of need for cooperation of many aspects of science to solve its problems, has brought about a situation in which one sees more clearly than at any past time the true nature of the problem and the rewards to follow its solution.

It has also become clearer that in its geological aspects, as well as in its humanitarian application, the study of earth movements must be conducted on the basis of world study. It is not merely the local structure and activities of the earth that we need for full interpretation of this subject; there must be available full knowledge of the conditions obtaining through and around the earth as a whole. The Third Pan-Pacific Science Congress now in session in Japan has offered an exceptional opportunity for consideration of world aspects of the problem. Arthur L. Day, Chairman of the Advisory Committee on Seismology, represents the Institution at these meetings, together with other members of the Committee, and will have opportunity to obtain a view of the situation which will be helpful in support of the program now under way in America.

Contribution to Discussion of Research

Carnegie Institution of Washington Year Book No. 25, p. 11, 1926.

The activities of the departments and investigators in making results of our scientific contribution easily available form a significant contribution by the Institution to advancement and appreciation of knowledge in the field of science. They stimulate the movement of research in the special subjects upon which we are engaged, and contribute toward corresponding advances in related subjects.

Our relation to the interested public, which reads on matters of science and utilizes all such material for guidance in clear thinking, represents an important opportunity for assistance in development of that attitude of mind in which use of facts and logic gives the basis

of judgment. It is clear that advance of science, and ultimate consolidation of results of research, depend in large measure upon the extent to which the public has opportunity to understand and to appreciate fully the meaning of the scientific method.

The Quarter Century Mark

Carnegie Institution of Washington Year Book No. 26, pp. 5–6, 1927.

The experience of the Institution during the quarter century of its effort to serve as a special means for advancement of knowledge furnishes material which will have real value in future study of the place of research in the scheme of human activities. It is too early for anything more than the most general statement regarding the meaning of accumulated data, but the trend of movement in organization and operation of the Institution is of significance in formulating our plans for future work.

In the early stages of operation, activities of the Institution were directed toward support of a relatively wide range of subjects, and the grants were commonly for specific projects and for limited periods. An important stimulus to constructive work in many types of agencies seems to have resulted. In time the tendency developed to direct effort towards certain major projects the solution of which required longer periods and greater opportunity for concentration of funds. This movement resulted in development of departments devoted each to its specific subject and under leadership of an investigator bringing exceptional vision and ability. The system of minor grants for special projects, or to distinguished individuals, was continued, but in many cases advantage was found in relating the problem covered by the special grant to work of a department of the Institution especially fitted to cooperate with the investigator. The result was a contribution consisting both of funds for support of and assistance by an actively investigating agency.

In later stages of the Institution's work, real advantage has appeared in a relation between departments comparable to that which had developed in some instances between departments and individual investigators. The favorable features of continuous, concentrated effort upon specific subjects in departments have been supplemented by active interest and support of related agencies within the same larger group.

The Institution today contains all of the elements that have arisen in the course of study of its problem. There are still widely distributed special grants. The greater departmental activities still represent concentrated effort in specific fields. The increasing mutual support has not diminished initiative of the individual or of the group, but it has added an element which with the passing of time becomes more and more valuable, both in effort to concentrate upon special projects and in keeping that view of the larger field so desirable in long-continued researches.

Relation of the Institution to the Public

Carnegie Institution of Washington Year Book No. 27, pp. 12–13, 1928.

Of the various types of contacts of the Carnegie Institution with the scientific and lay public the broadest and most definite influence has been through publication of results of researches. There is to to be counted in addition the direct expression of work completed appearing in lectures and exhibits presented in the name of the Institution. There is also the indirect influence unconsciously exerted through personal and administrative relations in conduct of regular operations of the Institution.

The influence of published results of scientific work is always far-reaching, but the total value depends in considerable measure upon whether the data are made available quickly and fully for the agencies, or interests, or groups of people to whom they can be most useful.

The contacts of the Institution with the outside world through its publication program have shifted steadily toward a position in which our technical books are printed and issued more quickly, obtain more diversified distribution through varying sizes of editions, are distributed to a wider group of agencies, and have broader and more rapid distribution to those specialists who have largest use for them. As indicated in earlier reports, various methods are now utilized by which, in a dignified way, the more generally used technical books have increased sale through the book trade, as is illustrated in the case of Sarton's *Introduction to the History of Science.*

It may not be wise to attempt translation of all scientific treatises into popular language, but it may be assumed that, with the plans

now developing, future years will bring an increasing group of publications of general interest in the form of books and by other means through which the wide-reading public may have acquaintance with the work as it proceeds.

The carefully prepared releases, arising from accounts of researches furnished by the investigators, and appearing in form acceptable to the public press, have served as a means of extending clear statements regarding work in progress to many millions of persons. There is increasing demand for such announcements, and there is reason to believe that they serve as an important medium for transmitting information regarding results obtained, both to the lay public and to the scientific world. For the coming year special arrangements have been made for issuing these statements, together with lists of publications, to all members of the Institution and to others who may be interested.

There is continuous study of the plan of the Institution with reference to methods by which the materials it produces reach those individuals, and groups, and institutions through which the knowledge obtained can become effective in human use. It is to be assumed that refinement of this process will not only give somewhat increased value to the work accomplished, but that it will also furnish a larger measure of satisfaction to those engaged in the researches through recognition of widened utilization and appreciation of results.

Development of Cooperative Projects: Seismology and Human Behavior

Carnegie Institution of Washington Year Book No. 28, pp. 13–16, 1929.

In the report of the President in 1921 attention was called to the opportunity of the Institution for aiding in the advancement of fundamental research through the use of its organization "as an initiating mechanism." Illustration was given of two fields in which informal committees might do important work in examination of critical subjects.

The regions for study specifically mentioned were seismology and certain fundamental aspects of human behavior. It was pointed out that in future geological science, examination of crustal movements in operation would have important bearing upon our interpretation of the nature of the Earth. In consideration of the second

group of researches it was suggested that carefully planned investigations in various aspects of biology now under investigation in the Institution would have value for interpretation of some of the more important problems in human behavior.

Two committees of distinguished investigators were invited to participate in examination of the problems proposed. In the course of the past eight years both lines of inquiry have been followed continuously. Both studies have now reached a point at which they have in a considerable measure attained the goal as originally visualized.

The committee of investigators in geology, geophysics, physics, and mathematics who were invited to participate in studies of seismology carried out a program which was concerned with development of new types of instruments, and with the setting up of projects for intensive study of specific regions on the basis of new methods. It has interested itself also in seismology as a world study related to the general problem of crustal movements. The results attained from year to year are noted in the reports of the President and of Dr. Arthur L. Day, Chairman of the Advisory Committee in Seismology, in the volumes of the Year Book since 1921.

For the investigation of certain special aspects of the problem of seismology it was considered important to organize a special program centering in a laboratory in Southern California. Through the cooperation of many agencies, including especially California Institute of Technology, such a plan was put into operation under extremely favorable conditions.

As a part of the plan of development arrangement was made to bring together the Advisory Committee and other specialists in this field for examination of the whole program as soon as the work should be sufficiently advanced to permit adequate examination of the mechanism in operation. The proposed conference was held during a period of two weeks in October of 1929. It resulted in a most interesting review of the status of investigation. The results of the conference emphasize the significance of this program as it has been formulated.

With this experience of several years in operation of the plan for seismological study in California, and the extremely important review of the project by the Advisory Committee, the status of the

work is so clearly defined as to make it evident that continuing development of research in this field will have large significance in geological science and its human application.

The investigations which have related more particularly to other parts of America, and to special localities in other lands, as illustrated by the work of Dr. Willis in Chile, Asia Minor, and Central Africa, have also illustrated the importance of correlated researches and carefully planned work of the cooperative type.

Operation of the Committee on Human Behavior has been even more informal than that of the Committee on Seismology. The meetings in 1922 and 1923 had as their major objective an attempt to define features of the problem of fundamental human reactions which might be reached to best advantage through studies of prenatal development and of the earliest stages following birth. It was recognized that certain of the aspects of development of the nervous system and its reactions in these early stages would have great importance.

Of the several phases of the problem the Committee expressed its view as to the exceptional interest, first, of an investigation of development of the morphology and physiology of the embryo with particular reference to reactions of the nervous system; second, as to intensive study of the reactions of the newly born individual; and third, as to the study of corresponding reactions of other organisms, especially those of types closely related to man. In the effort to follow out these types of research the Department of Embryology of the Institution was recognized as the natural instrument for furtherance of studies of the first group. The progress through this Department in the field, considered of such importance by the Committee, presents a record in which the Institution may well have pride. The study of development of higher animals through this laboratory, as illustrated in the work of Dr. Hartmann in his research on monkeys of the macaque type, is one of the significant contributions in this field.

In study of the corresponding reactions of higher organisms related to man, special consideration was given to a program by which Dr. Robert M. Yerkes aimed to develop facilities for research on the higher anthropoids under conditions favorable for breeding and for extended study. In another direction an effort was made to assist in the organization of stations at which, for purposes of special

research, the gorilla might be examined under the conditions of its original habitat.

The first of these two programs relating to study of higher animals similar to man has been realized as the result of establishment of research on a most satisfactory basis by Yale University, with the support of the Rockefeller Foundation. The second project, relating to study of the gorilla in its normal environment, is realized by the extremely significant action of His Majesty, the King of the Belgians, in setting aside in Central Africa an area, originally pointed out by Mr. Carl Akeley, which is exceptionally well fitted to be a preserve for biological and psychological studies of certain aspects of this peculiar fauna.

Relation to the Public

Carnegie Institution of Washington Year Book No. 29, pp. 16–17, 1930.

To carry out a program corresponding measurably to the opportunity of the Institution, it is necessary that quarters be made available which would give rooms for conference of groups of Institution investigators along with representatives of other agencies. There should be available a small group of offices which could be used for visitors engaged upon study of special questions. It is necessary also to have an auditorium of modest dimensions, which would accommodate audiences interested in the type of presentation of research results which has been carried forward successfully in recent years. Development of equipment of this nature should include some extension of the quarters designed for handling of publications of the Institution, including both technical monographs and those contributions which have to do with interpretation of our results.

Determination of policy of the Institution with reference to these matters probably represents one of the most important questions for consideration at the present moment. Adequate expression of this aspect of work of the Institution may not be considered as indicating trend of interest away from fundamental research activities. It is to be thought of only in the light of means through which work done by the Institution may attain a relatively high value for the scientific world, and also for the interested public. It is probable that long-continued research activity without attempt

to offer means for interpretation would definitely reduce the value of results obtained by the Institution.

The tendency of modern science, philosophy, and education is to recognize that advance of knowledge does not depend merely upon accumulation of facts. There is involved, as one of the most important features, the relation of these facts to others, and such a degree of interpretation as will permit attainment of their largest human value.

Research and Human Service; Ending the Third Decade

Carnegie Institution of Washington Year Book No. 30, pp. 2–7, 1931.

With the ending of the second decade attention was turned toward functions of Institution research under a type of stress in which every human resource had been tested by stimulus and strain of war. In the present year, ending a third decade, we may not avoid considering values with the reaction of depression as a dominant feature.

Within these two periods research has not been characterized by an even flow comparable to movement of passing years, but the volume has increased gradually with emphasis placed now here, now there.

In each period of emergency there has been intensive study of the place and function of research with reference to needs of the special situation. There has been vigorous search for new materials with which to meet the requirements. But in spite of earnest endeavor, it has rarely been possible to secure aid through new research. The major achievements have been reached commonly by inventive use of existing materials through recombinations. These situations, however, exert large influence in stimulation of research. They serve to show that, with a considerable spread of years between the inception of a new and fundamental idea and its human application, there must be continuous study of those more clearly basic things upon which future science and its application will rest. If necessity is mother of invention, and invention is in considerable part the creative reorganization or combination of ideas and materials at hand, we must advance those types of fundamental work that produce the data which invention will use.

From another viewpoint, experience in recent decades has fur-

nished important lessons bearing upon questions of organization, dissemination, and application of research results. If human emergencies are met commonly by the inventive or creative application of materials already at hand, it is necessary that, as a part of the movement to forearm, we prepare by adequate organization and by wide, carefully planned dissemination of information as it becomes available. Such activity is naturally the duty of education, but the first responsibility lies with agencies from which the material is derived. It is part of the function of these institutions to see that the data come into use, and that they become available in the many fields through which one might expect them to be applied.

Among recent attempts to find means for adjustment in the unbalance of present day civilization is the suggestion of a moratorium on research. The part which science plays in development of the present-day environment is probably large, and it is not surprising that in this situation honest suggestion has been made regarding its influence. According to one view, too much new knowledge confuses us. From another side it is intimated that in some way research is responsible for maladjustment in the rapid development of heavily mechanized modern life.

That heterogeneous, unorganized new ideas may be dangerous to society is clear. This would be illustrated by use of new chemical compounds or newly discovered types of physical energy applied inexpertly in medical practice. Similar results may arise from unwise economic promotion in connection with introduction of new mechanical devices. Harm can be done through unwarranted philosophical or religious application of incomplete scientific hypotheses. But the evils which develop are not necessarily to be charged against the new knowledge as such. Generally they are compounded from inadequacy of knowledge and failure to recognize the need of additional correlated information. Human frailty taking the form of selfishness in use of new materials is a menace coordinate in significance with the dangers of ignorance and bad judgment.

Science is only the truth about ourselves and the world around us, but truth in partial statement must be interpreted carefully and applied with every precaution until the story is seen to approach completeness.

The safety of humanity does not require a moratorium on increase of honest knowledge. While half truths and unorganized or unrelated facts constitute a real source of danger, what we need is more truth and the acceptance of knowledge for precisely what it is. Along with new information it is essential to have guidance regarding what to accept as fact and what to consider as merely tentative grouping of ideas for the purpose of testing theories.

If the great volume of new data coming out of constructive work could be so classified and interpreted as to give us a clear picture of the actual state of advance in knowledge, and to make possible also some appreciation of relation between the various fields, there would be no suggestion that the progress of research be retarded.

Experience of the Carnegie Institution has indicated that even in an agency which deals with exploration of new or little known problems, it is essential to have clear definition of objectives, well-planned organization, continuing acquaintance with the degrees of achievement, and adequate provision for use of the products of research.

Full recognition of the ideal of human service suggests that, since the investigations of the Institution are largely of a basic type, adequate utilization of the materials produced requires placing them where they can have immediate and effective use by types of agencies more specifically concerned with application.

The changes in objectives, organization, and plans for use of results of the Institution's work as viewed over the three decades of its existence show increasing clearness of vision as to importance of the work undertaken, and as to definition of objectives for researches in an institution of this character. The organization of the Institution has changed from that of slightly related individuals or groups to an agency with distinct unity. Along with advance in effectiveness of the group as a whole, there has been increased advantage to the individual investigator. And with other changes there has been distinctly increased emphasis upon constructive use for the products of research. Planning for effective and dignified dissemination of information obtained through investigations of the Institution expresses itself from the time when the new problem is visualized until the research is finally set aside as representing the best result that existing conditions permit.

The spirit which has actuated all members of the Institution

justifies the belief that honest endeavor in search for truth contributes an important element of hope for the future. Moreover, it is important to appreciate that recognition of this point of view is essential in consideration of the purely human questions, as well as in study of physical and biological elements. As we see close at hand the end of man's age-long struggle with the wilderness of nature through which he has come, it is important to realize that life in those jungles which arise by human construction requires not less, but more, of the type of ability that has characterized human progress to the present stage.

Application of Research Results

Carnegie Institution of Washington Year Book No. 31, pp. 4–7, 1932.

The intense concentration upon critical questions which is possible in an agency devoted to fundamental research gives exceptional opportunity for contribution to knowledge. Long-continued operation increases the possibilities in such a program, provided enthusiasm for the subject is maintained. Question has sometimes been raised whether there is danger that in such an organization uninterrupted pursuit of purely idealistic aspects of science may work disadvantageously through turning attention away from what are called the practical realities of life. Is it possible that, by reason of this situation, a considerable percentage of the values observed will fail to come into human use? Consideration of the opportunity for human service which an agency devoted primarily to research can have through application of its results will always be important in reviewing the program of the Institution.

Between fundamental research and the incidents of day-to-day living the gap may seem extremely wide. So broad does this space appear that investigational activities are sometimes assumed to have value solely as intellectual exercise. This possibility is inherent in a case of this nature, since research concerns exploration in unknown fields. If we had acquaintance with the areas under investigation, the operation would not be research. Where studies are set up for the purpose of carrying knowledge forward along lines already laid down, it may be possible to make approximate prediction. But if the situation were fully known, the work would be merely verification and not fundamental research.

In the field of the unknown the paths are rarely well defined, and the process of exploration involves following clues leading now this way, now that. Sometimes the results are negative, but the contribution serves, none the less, to mark limits of knowledge. Not infrequently there appears to be complete separation from everything having to do with practical living, but this does not diminish the ultimate value of results. It is also important to remember that the challenge of adventure in unknown regions, and the lure of possible discovery, make work of this type so attractive that accumulation of information continues.

Once the boundaries of knowledge have been moved forward, it becomes important to know the values represented by such advance. The time has long passed when it seemed desirable to inquire whether information about the universe or ourselves could exist which would not have human value. The unity of knowledge as we now begin to conceive it indicates that ultimately everything attains its place. That which seems insignificant may finally appear among the most important influences in life. Such is, in part, the justification for a program of intensive effort devoted to advancement of knowledge in the spirit of human service.

In development of research under conditions of modern social organization it is essential that such a relationship be set up as will make possible the greatest service through investigation, and at the same time permit the fullest use of what is secured.

Attainment of the highest values in an institution devoted to research depends in a measure upon the extent to which touch can be maintained with the fields of application, education, stimulation, and spiritual refreshment through which they may contribute to life. With this aspect of our problem in view the Carnegie Institution has recognized three important phases of its responsibility relating to the use of research contributions. These activities include, first, a scheme for permanent and detailed record of results coming from researches, and so placed that they are available to specialists in all fields of science. To meet a second responsibility, continued effort has been directed toward study of the broader interpretation of work accomplished, and toward statement of conclusions in such manner that they may have the widest possible research and educational use.

Arising out of our program, there is now developing a third series

of studies, designed to review research activities having application aspects so important that united effort of all contributing agencies may be desirable.

The most significant illustration of study on application problems is furnished by the work of a group of representatives from various departments, which is concerning itself with examination of investigations that may be helpful in dealing with critical questions of medical research. In developing this study it is not the intention to set up within the Institution activities corresponding to those of a medical research institute; nor is it necessarily true that fundamental modification of existing investigations would be brought about for the specific purposes of medical research. It is, however, desirable that resources of knowledge available within the Institution be placed at the disposal of investigators in other special fields, with the minimum of effort and the maximum of effectiveness for utilization.

Interrelation of Researches

Carnegie Institution of Washington Year Book No. 31, pp. 8–9, 1932.

In addition to wide cooperation between the Institution and research divisions of other agencies, one of the most important aids in the advance of investigation has developed through intimate relationship among research groups of the Institution itself.

With the departments and divisions situated where the conditions have been found most favorable, wide geographic distribution has been inevitable. But linking of interests is a stronger influence in the positive sense than is geographic separation viewed as a negative factor. The need for mutual support, and the stimulus of opportunity offered through the annual conferences and exhibits, has led to development of many connections having large influence in furtherance of the entire program. A factor of real significance in advancing some of the most important researches of the Institution is found in recognition of the possibility that, in extreme refinements of study, materials secured by specialists in other fields may be the elements most needed for success.

A very interesting statement of this problem, as it appears to one of the leading investigators of the Institution, is presented in the

following abstract from a recent paper by Dr. Frederick H. Seares, of Mount Wilson Observatory:

. . . These interrelations are important because they greatly increase the scientific effectiveness of the Institution.

Everyone knows the contributions that come from highly specialized research, how little by little they increase our knowledge of the world in which we live, bring benefits to humanity, enrich our intellectual lives, and in the end subtly shape our thoughts about man's ephemeral existence in a universe whose duration eludes comprehension. It is not always recognized, however, that these results come about much faster when the specialist follows up connecting threads that lead into other fields of research. He then often finds an unsuspected interdependence which solves many riddles. Thus we learn much about plants by studying the animals that inhabit the same region. Plant distribution is a matter of soil and climate; more fundamentally it is a matter of geologic change, and only the paleobotanist, backed by the geologist as well as the physiographer, can tell why Monterey pines and redwoods grow where they do today. The life of the sea fluctuates with the physical-chemical conditions of its waters and is, therefore, also to be studied from the viewpoints of geophysics. . . . Cycles in tree growth point to fluctuating rainfall, which may be related to changes in the sun. Geology is linked to geophysics, while the geophysicist tells us how to make glass for our telescopes. Terrestrial magnetism offers analogies for the magnetic field of the sun. Physicist, geologist and geophysicist combine to investigate earthquakes, and with the astronomer they study the surface features of the moon and tell us its substance.

. . . Basic for all these things, of course, are the researches of the physicist and chemist and the powerful methods of mathematical analysis. The constitution of a star is a problem in atomic physics. The Carnegie Institution therefore aids Millikan and Noyes at the California Institute in order that they may join with the Mount Wilson Observatory in studying the constitution of matter, and supplements these efforts in its own Laboratory of Terrestrial Magnetism in Washington. It helps Michelson to repeat the famous Michelson-Morley experiment and to redetermine the velocity of light. In turn the astronomer directs the physicist to the stars as laboratories presenting conditions of pressure and temperature unattainable on the earth, under which he may test his theories of atoms.

Influence of Present Emergency upon a Research Institution

Carnegie Institution of Washington Year Book No. 32, pp. 4–11, 1933.

For institutions established with expectation of a short period of service, social, economic, and political changes may have relatively small significance. In those designed to give continuing and developing service, policies may be altered radically through adjustment

to changing social conditions. But the longer programs may rest upon fundamental factors which are either not affected immediately by ordinary changes, or are of such a nature that shift in conditions tends only to increase importance of the undertakings.

In the history of this country, the place of research among factors touching needs of advancing civilization is illustrated by its relation to the broader features of our economic experience. Abundant development of natural resources has produced great wealth and the advantages which flow from it. The period of harvesting these materials has been followed by one of extraordinary mechanical and industrial growth. At the present moment the natural resources are well known and adjusted to future use. Further advance depends largely upon research, inventive genius, and human organization. New ideas ranging from those arising out of physics, chemistry, and biology on into laws of history, problems of economics, social values, governmental principles, and the more fundamental understanding of human behavior have come to take primary place in classification of our needs.

It is difficult to visualize a situation in which we could retreat from the present position. The needs of civilization can never be met by a static condition in which the generations merely settle down to life at a particular level. One can assume that through coming ages the requirement for increased knowledge with new ideas and their bettered application will grow. Unusual constructive ability arising out of what is known as the scientific interpretation will have an increasingly important part in development and organization of society. The investigational process, both as a means of securing ideas and as a method for learning their application, will naturally and properly take its place as one of the most nearly indispensable of all activities upon which the future well-being of mankind depends.

Under conditions of the present and future, it is essential that, along with other types of agencies, we have institutions devoted primarily to the broader aspects of research or constructive development. It will not suffice that this phase of human activity be relegated to a place of secondary importance. Certain of the organizations devoted to this work should have sufficient scope as to subject, and adequate breadth in geographic location, to represent the wider picture of investigation.

It is not to be expected that any research institution will cover every special subject, or even every aspect of investigation in any given field. But it is desirable that there be agencies in which the broad view will be clearly expressed, and at the same time the more intensive aspects of specialization be represented. A close relation between the concentrated type of investigation and that characterizing the broader view would be one of the natural requirements of such an institution.

The development of great research programs in the industries is one of the unequivocal evidences that the constructive aspect of activity is humanly important. The tendency in universities to voice the idea that the primary function of these institutions is advancement of knowledge is further indication of belief that the investigational type of activity is a major need.

That by reason of great economic changes an agency set up like the Carnegie Institution, with support by endowment, might gradually fade, and its particular functions be carried on through other types of activities, is one possible way to view the program upon which it has embarked. To the founder of the Institution this organization was not just a satisfactory means of spending a certain sum of money. The idea as originally stated concerned the importance of continuing and intensifying emphasis upon that attitude of mind that tends in the most effective manner "to expand known forces, to discover and utilize new forces for the benefit of man." In choosing to make investment in a phase of activity that concerned continuing development, Mr. Carnegie initiated a work for which, by reason of the nature of human kind and of the universe in which it resides, we see increasing requirement so long as man exists. Though the emphasis will vary as to subjects, as to needs, and as to manner of application, the attitude of open-mindedness and the research mode of approach will continue to increase in importance.

In periods of emergency shifting conditions may tend to press toward extinction of research and research institutions through financial weakening, and because of emphasis on what may be considered essentials of life. In another view, emergencies present tests of adequacy in research as a method and as to human value of specific ideas for the origin of which it is responsible.

In the type of emergency through which the world is now passing,

multiplicity of problems, and the influence of depression as contrasted with the accustomed progressive tendencies of other days, turn attention sharply to our needs for knowledge and for scientific judgment. Whether or no we find immediately the curative and constructive factors required to guarantee the kind of forward movement which mankind hopes to see, no question exists as to the requirement for fundamental and far-reaching knowledge bearing upon an almost infinite number of elements involved in the present situation. Nor is there doubt as to the necessity for clear interpretation and faithful human application of the information sought.

There was never a larger demand for further information and its human use than at the present moment. That this requirement is in considerable part within the relatively difficult fields of economic, social, and governmental problems seems only to emphasize the importance of such demonstration of the method and approach of research, viewed broadly, as will guarantee advance in consideration of new problems on the basis of full knowledge. Under present conditions the significance of research is destined to have increasing recognition, provided there is opportunity for such expression of the results that they may fit accurately and appropriately into the complex mosaic of human interests, and ultimately attain a place among those elements that concern normal movement in development of life.

Unfortunately the complex mechanisms needed in successful research commonly require concentration such that, with stress placed on work of construction, the results may fail to reach and influence other science, or general human interest, or specific human application. Although original investigation which produces new information is the critical operation upon which the greatest concentration of attention must always focus, it is also true that discovery alone may not represent complete or adequate advancement of knowledge. Recording of results, interpretation of what has been obtained, and satisfactory placing of the materials constitute important elements in the process. Unless care is given to handling of information derived from research, there may be waste or loss of real values secured. It is also important to realize that interpretation of such data partakes both of science and of that art through which its expression may be most effective.

What we call the emergency of the moment is in a measure occa-

sion for awakening of interest and that sharpening of vision which can give to the inquiring or constructive attitude of mind, and the products of its effort, a human value not previously recognized. Opportunity for utilization of this mode of approach to knowledge by means of the great variety of activities represented in an institution devoted to the cause of research may, under conditions of the present epoch, bring to realization in an exceptional way the kind of service which Mr. Carnegie visualized for an agency which would continuously devote itself to the cause of "discovery, and the application of knowledge to the improvement of mankind."

Obligations which may be assumed to rest upon an institution of this type, in a situation such as now presents itself, are susceptible of definition only in general terms. But opportunities for practical application will appear as new problems of importance to the community relate themselves to special activities of the institution. Situations are conceivable in which, from the advanced position of newly developed knowledge, interests which concern the country broadly will be discovered by research workers before they are known to the community. In such cases the initiative for action may be taken by investigators. The interests of this Institution and those of the country and of mankind broadly are one, and under conditions of stress it is important that all possible contribution be made toward aid in the public cause.

In many and unexpected ways new and complex problems of this particular period have shown the need, not only of experts concerned with extremely specialized subjects, but along with these the requirement for investigators who can bring knowledge across the boundaries from one field into another in which it may have relatively high value. Many problems which focus in economics or government, but arise through consideration of special questions in the natural sciences, require this close cooperation of workers in different fields.

In a period of wide uncertainty the maintenance of schedules for activity means not only employment but with this it concerns elements of morale, both in the sense of occupation and with reference to confidence in the value of knowledge and its development.

The present general program of the nation, and in reality of the world, is hopefully described as recovery, but the vision that dominates thought in questions of this nature does not concern merely return to earlier conditions. What we really desire is advance to

the stage that should be, or should have been attained. Out of present reorganization activities it is probable that much of the most vital thought relates to what may be recognized as having future value. It is in questions of this nature that the trained investigator may see not infrequently the elements of progress so much desired.

Less clearly tangible than other relations to present and future conditions, but not less critical, is the significance attaching to maintenance of standards in thought and objectives. Investigation is search for the truth regarding all manner of things in the heavens above and the earth beneath, in the fragmentary details concerning life of past ages, in structure of infinitesimal cells and atoms, in the deeper recesses of minds which we call normal and in those that suffer from various ills. But it is always the truth and its relation to other truth that we seek. One could go far toward demonstrating that an institution dedicated to research would justify its existence abundantly if it did nothing more than bring to the world the significance of this type of work as aiding to give evidence of the value of real things and their true relation to each other. There may be a long gap between the meaning of electrons, nebulæ, trilobites and enzymes on the one hand and great economic and political problems as they express themselves in life, but the future will unquestionably show that, wherever we work, full value given to realities, whether they concern the existence and nature of things or purposes of action, affords the largest guarantee of success in what we strive to accomplish.

Cooperation with Individual Investigators

Carnegie Institution of Washington Year Book No. 32, pp. 26–27, 1933.

In advance of knowledge through research, the results attained may have value without reference to the means by which they are secured. The product of activity arising from investigation may continue to make its contribution after the physical instruments, the theories, and personalities concerned have disappeared. But this is not the normal situation. Commonly, as researches actually develop, there are great possibilities for influence by the personalities through which results are realized. Also, the method by which a specific contribution is made may be enormously important both

in conduct of a particular study and through other types of investigations located in distant fields. The value of such research methods and of their by-products may be especially large for investigators whose interests touch the particular problem under examination. It is therefore important that in the conduct of researches opportunity be open for cooperation with other investigators in related or even in distant fields of study.

At the same time it is important to recognize the influence of such developing researches upon those who are beginning with interest and enthusiasm to take up the field of studies involved. Such contacts mean the passing on of the torch as it is represented in actual knowledge, and more especially through point of view and inspirational value.

The influence of personal relationships in stimulation and advance of research is recognized as of great significance in educational institutions. Its value is not less in the work of an agency such as this Institution devoted specifically to investigation. It is important that, so far as possible, opportunity be given for cooperation which will aid research in fields related to those in which the Institution is engaged. It is of course true that the particular types of influence represented will in general concern themselves principally with subject, material, and modes of approach illustrated in an important way in the special kinds of research carried on in this Institution.

With full appreciation of the value in such types of cooperation for advancement of research in the broadest way, departments of the Institution have, over the years, given increasing aid to other agencies and institutions so far as our facilities have made this possible. During the past year a small group of departments of the Institution has been able collectively to give cooperative aid for considerable periods to approximately sixty persons.

Ultimate Values of Research

Carnegie Institution of Washington Year Book No. 33, pp. 37–41, 1934.

An interesting opportunity for study of scientific values is offered by the program of the Institution involving conduct of fundamental research leading to technical publication, followed by some measure of interpretation and inquiry regarding application. The vigorous discussion by scientists and philosophers concerning worth or significance of research contributions has centered in considerable

measure around questions which have to do with maintenance of life, with amelioration of adverse physical conditions, and with factors assumed to affect the economic or social balance.

As yet comparatively little attention has been given to the idea that science may have made its most noteworthy contribution through influences which aid in determining attitudes of mind and objectives. In other words, we have been concerned more largely with discussion of the extent to which science affects our environmental conditions than with the possibility that it helps to give us new points of view and a bettered attitude toward life. The great significance of this difference becomes apparent when we consider that influences determining point of view and attitude furnish major sources of human initiative, and are among the most important guiding elements in life.

Science has made vast contribution toward betterment of living conditions through ready production both of necessities and luxuries, and by freeing us from drudgery. But abolishing poverty in the material sense might not prevent poverty of mind and soul. Increased freedom from the labor entailed in maintenance of life may still leave us enchained in spirit. Wealth in the sense of natural resources or accumulated results of human toil, or even expressed through increase of capacity for work might lead only to degradation. There may be wickedness and bitterness and infinite discontent with riches and great power. Whether the world really becomes a better place in which to live depends in large part upon out attitude toward life and our ideals. If science and research help to improve these controlling factors in life, they attain the supreme service. If bettered point of view can arise only from other sources, then science and civilization must wait until some way is found by which there may be exerted the power necessary to bring about the change desired.

The influence of science upon our point of view and ideals may be thought by some to be negligible, since the attitude involved will be assumed to depend upon spiritual values, and research is looked upon as concerned only with cold facts and logic. It is, however, important to realize that by definition science represents the seeking for truth, whether it relate to the elements of physics, chemistry, history, or human conduct. The use of reason is only the logical extension of truth. Facing the facts by the method of science is to

strip away untruth, dishonesty, self-deception. This may be by changing alchemy to chemistry, the rabbit's foot type of healing to scientific medicine, wishful thinking to factual economics, or self-centered beliefs to constructive religion.

It must also be recognized that a view over the vast range of things expressed through science as in astronomy, earth building, biology, or the story of life through the ages, gives a greatly increased appreciation of law and unity in the world. Such a view includes all history and our relation to it. It presents a new outlook over the universe, with a clearer vision of man's place in the scheme of things, a better opportunity for appreciation of what life represents, and a changed attitude toward its problems. Seen in this light, science should aid in the forming of basic beliefs and philosophy, and even religion may use it as material with which to build. Science gives reasons why every man should have a philosophy and admit it, and at least an appreciation of what religion may signify.

In considering the relation of science to those fields of thought which are generally deemed most clearly to express human interests, it is desirable to suggest that the difference in attitude among these subjects is not necessarily as great as is sometimes assumed. Science finds need for common ground with philosophy, art, and religion in the work of developing a clearer, broader, and deeper vision of the world of things and of people about us.

As seen by science, the universe is a vaster and more orderly, more dependable place in which to live than was once recognized. At the same time the scientist may appreciate more clearly today than at any previous stage that he does not really fathom nature in essence, or power, or ultimate meaning. With the advances made by modern science the so-called material universe does not grow more definitely material, or at least one may say it is still beyond our full understanding. And for these reasons we need close relation among the various points of view which we may take. The interests of science, art, philosophy, and religion must be joined if their human value is to be most fully realized. Each may stand alone as an abstract or non-human value, but when human interests are touched they must come into intimate, mutually supporting relation.

Science we see as a powerful educator because it turns attention to real things, and not to substitutes. One can not dismiss the idea

that these expressions of reality and law relate in large part to things other than mere food and maintenance of life. We need wide acceptance of the attitude of mind illustrated by science in searching for facts upon which to base judgment.

One Hundredth Anniversary of the Birth of Mr. Carnegie

Carnegie Institution of Washington Year Book No. 34, pp. 1–5, 1935.

At a time when interest in the great constructive work done by Mr. Carnegie in various fields of education, science, and culture is emphasized by the one hundredth anniversary of his birth, it is fitting that there be included in this report reference both to the original aims in founding the Institution and to the trend of activities which will determine ultimate appraisal of accomplishment. In considering this relation between aims and achievement, one may not avoid noting that the Year Book series in which this report appears is the most comprehensive statement in existence regarding work of the Carnegie Institution. The thirty-four volumes of this series constitute a detailed report and a history of activities initiated by the Institution since the date of its founding in 1902.

The objectives of an agency like the Carnegie Institution can not be defined with such mathematical clearness as to permit adequate report in statistical form. But without evident appreciation of purposes or aims a statement concerning development of the activities might have relatively little value. Although the purposes of the Institution are known in general terms through reports upon its researches, there may be marked difference between a statement to the effect that something has been done and a record formulated with relation to objectives. A report properly requires examination of the program as it has developed and of achievement in terms of the ideas visioned by the Founder.

In the long list of activities to which Mr. Carnegie devoted his efforts, the use of opportunities considered most desirable found expression in many kinds of institutionalized programs. The purposes defined appeared to vary widely, though in many ways these apparent differences were only the statement, by various means, of basic ideas which guided Mr. Carnegie's thought. The whole group would probably have been found closely related in his view of the greatest needs of the time.

In the decision that large personal possessions should, so far as possible, be turned to use in the interest of the people, for furtherance of major ideas urgently needing intensive support, Mr. Carnegie emphasized, among other things, dissemination of knowledge through the library, and the study of fundamental educational problems and economic security of the teacher through the Carnegie Foundation and the plan for teachers' pensions. Art, the museum, technology, and education broadly were furthered by Carnegie Institute, at Pittsburgh. Self-sacrifice and courage were recognized through the Hero Fund in the United States and similar funds abroad. Study of difficult, but vastly important, problems of world relations and peace was the objective of the Endowment for International Peace. As concrete projects relating to what seemed of immediate importance, he aided the peace movement through building the Palace of Peace at The Hague and establishment of the Church Peace Union. To provide opportunity for conference and discussion on international problems of the Americas, he made possible the home of the Pan American Union in Washington and of the Central American Court of Justice in Costa Rica.

For the immediate benefit of the community in which he was born, for the advancement of education, and for the well-being of people of Great Britain and Ireland, Mr. Carnegie established the Carnegie Dunfermline Trust, the Trust for the Universities of Scotland, and the United Kingdom Trust.

Along with the splendid group of activities already mentioned, the Carnegie Institution of Washington was founded on January 28, 1902, "to encourage in the broadest and most liberal manner investigation, research, and discovery, and the application of knowledge to the improvement of mankind." In 1911 the Carnegie Corporation of New York, representing broadly the general activities in which Mr. Carnegie had been engaged, received the remaining large means for aiding in such projects as might be considered worthy of support in promoting "the advancement and diffusion of knowledge and understanding among the people of the United States," and with these means for benefaction was included a special fund of ten million dollars available for activities in the British Dominions and Colonies.

Appreciating the necessity for uninterrupted advancement of knowledge and intellectual growth, for realization of which con-

tinued investigation, research, and discovery would be required, Mr. Carnegie saw also the need for maintaining study of the methods by which such advance could best be made. The organization and planning of the Institution were, therefore, so designed as to leave freedom of action such as would make possible the most effective development of program in the light of changing conditions. This was recorded in Mr. Carnegie's statement: "The specific objects named are considered most important in our day, but the Trustees shall have full power, by a majority of two-thirds of their number, to modify the conditions and regulations under which the funds may be dispensed, so as to secure that these shall always be applied in the manner best adapted to the changed conditions of the time; provided always that any modifications shall be in accordance with the purposes of the donor, as expressed in the Trust, . . ."

With reference specifically to the objectives which Mr. Carnegie had in mind in establishing the Institution, it is important to note that there was involved both the idea of research and discovery, in the sense of acquaintance with new materials and new ideas, and with this the desire "to expand known forces, to discover and utilize unknown forces for the benefit of man." It is interesting to observe that the expression of purpose did not end with the idea that this was merely for the *benefit* of mankind, but the activity was stated to include as well "discovery, and the application of knowledge to the *improvement* of mankind."

A student of history might incline to interpret Mr. Carnegie's statement regarding "improvement" as meaning that he expected the human race to better itself continually through an evolutionary process. Whether or no this was specifically the idea in mind, it is clear that Mr. Carnegie thought not only of the "expanding of known forces and the discovering of unknown forces," but that he had in view activity leading to continuing development and improvement. Whatever views we may entertain as to ultimate good in the philosophical or religious sense one may not doubt that the idea of forward movement in the wider range of knowledge, of better means of application for human use, and of uninterrupted growth in intellectual as well as in spiritual stature, represents a condition offering an infinite range of achievement and of hope. However other goals may be defined, the way leading to a place or a condition with evident possibilities for improvement will be looked

upon as having special importance when it offers opportunity for progress leading to more progress.

Development in Methods and Organization of Research in the Institution

Carnegie Institution of Washington Year Book No. 34, pp. 5–12, 1935.

As has been indicated in many earlier reports to the Trustees, the work of the Institution was initiated with numerous relatively small grants which were commonly made available to individuals. By this means it was possible to select both outstanding projects which needed special support, and exceptional individuals whose ability and interest it was important to have turned toward constructive study.

In the preparation of a working program for the Institution which should give effect to the purposes of the Founder, the Board of Trustees upon organizing in January, 1902, appointed eighteen advisory committees, each committee representing a recognized department of knowledge. These committees were invited to canvass the needs in their respective fields and to make such recommendations relative to procedure as they believed would "advance with wisdom the great purpose of the foundation." It is to the reports of these committees—reports that sought to give definitive expression to the vision of the Founder—that Carnegie Institution, as it now stands after 34 years of growth, traces its roots. The published reports of these committees represent in themselves an extremely interesting stage in the development of research in America.

The Institution of today differs in some measure from the Institution of early years in administrative structure, in method of work, in program of research, and in relationship to educational and investigational agencies as well as to the general public. Yet the changes that have ensued are but progressive responses to altered conditions, on the one hand, and to slow but steady conquest, on the other.

That the Institution today, with all its differences, remains as much an expression of the Founder's ideals as it was thirty years ago is remarkable attestation to the breadth of the Founder's vision and to his great wisdom in creating an organization sufficiently flexible to adapt itself to situations that are ever changing.

In considerable measure as the result of studies by the special committees, work was initiated upon projects which required concentration of interest and effort of groups of specialists concerned with major problems. As this evolution of method and organization advanced, to some it may have appeared to lead toward a situation quite different from that suggested through Mr. Carnegie's original ideas.

But what seemed to be a fundamental shift in program leading to support of larger projects, and to the coöperation of considerable groups of individuals, has in some respects tended to emphasize significance of the exceptional man more than might have been done by continued use of the smaller grants to individuals conducting their researches independently. Organization of departments, and ultimately of divisions, while appearing to require sharper definition of limits for individual activities, has served to bring about concentrated attack by individuals having specific interests in common problems the solution of which could be obtained only by such coöperative effort. In some respects the results have brought increased opportunity for the individual with exceptional vision and leadership, and at the same time have increased the possibilities of advance in research for others with intense enthusiasm and showing exceptional devotion to research.

Illustration of the type of activity which developed in departments is found in the organization of the Geophysical Laboratory, Mount Wilson Observatory, and the Department of Genetics.

In the Geophysical Laboratory, established in 1907, a group of researches was turned toward what has sometimes been called the dark continent of the interior earth. Requisitioned to this service, every value which could be derived by application of chemistry, physics, geology, volcanology, and ultimately seismology, has been used in study of a region in some ways more difficult to reach than the stellar universe about us. Another illustration of this method in the physical sciences is that presented by Mount Wilson Observatory, founded in 1904, and dedicated to the study of the sun, as the star most easily accessible for observation by telescope, spectroscope and all instruments which can give us knowledge of the morphology, physiology, chemistry, and physics of that great physical unit upon which the existence and development of life on the earth depend.

Still another illustration of necessary coöperative effort is found

in establishment of the Department of Genetics, originally set up as the Station for Experimental Evolution in 1904 and later combined with Eugenics. Upon the intimate study of lines of inheritance, and the factors involved in development of the individual, and origin of the species and related groups, there has been concentrated the life work of many individuals operating through what have seemed widely different regions of investigation, but which are all concerned with the nature and mechanism of individual and racial or group evolution.

In 1927, several phases of related Institution activities in plant biology were brought together in a Division comprising a wide range of problems extending from experimental taxonomy through ecology, investigation of desert problems, basic studies on the biology of tree growth, relation of climatological research to periodicity in tree growth, problems of photosynthesis, and palæobotany. Brought into this close relation, new and important developments in plant study have been made possible.

A Division of Historical Research was established in 1929 to bring into the most effective relation groups of studies covering aboriginal American history, a section concerned with the history of the United States as expressing the influence of western European institutions upon America, and a third section comprising studies in the history of science with special reference to its influence upon civilization. To these researches is related a considerable group of studies concerned with the early history of man as it is read from the geological record.

In 1934 a Division of Animal Biology was established as the natural outgrowth of effective and fruitful conferences covering research in genetics, nutrition, embryology, with other aspects of biology including a wide group of activities held together by interest in many common problems.

Within the past year the continuing importance of relations among the organized activities of the Institution in the field of the physical sciences has led to setting up of a committee to facilitate study on the increasing number of common problems appearing in these fields. This committee will also make more easily possible the development of special projects representing interests of several departments.

The contributions already made through coöperation of groups of

investigators in the physical sciences have been extremely valuable, and with the rapid shift of emphasis in physical problems one may expect continuing development of new fields requiring special facilities for investigation. In the physical sciences, as in the other research groups of the Institution, it is assumed that better definition of facilities for interchange of data and for coöperation will aid in solution of problems requiring concerted action by representatives of rather widely differing disciplines or modes of approach.

Good illustrations of what may be accomplished in such coöperation are found in the study of relation between solar activity and radiation, at Mount Wilson Observatory, and variations in magnetic conditions on the earth, forming the subject for continuous investigation by the Department of Terrestrial Magnetism in Washington. The noteworthy contributions by the Moon Committee, involving several departments together with investigators from other institutions, have not only given us a better understanding of the moon, but have furnished data of value in study of the surface of the earth and of other planets.

One of the most important achievements in the field of Institutional activities involving concerted effort of several institutions is represented by the Seismological Laboratory at Pasadena, planned and developed through the work of the Advisory Committee in Seismology under the chairmanship of Dr. Arthur L. Day, Director of the Geophysical Laboratory. Although seismology may well be claimed as a phase of geology, comprising as it does the study of inner features of the earth, the work of this laboratory was organized on the basis of coöperation with the geological, physical, and mathematical groups at California Institute of Technology and other institutions. Under the wise guidance of the Advisory Committee, many types of interests have been directed toward study of earth movements, and have made possible achievements of exceptional significance. The ultimate values in what has been obtained through this unique project, involving coöperation of many agencies and institutions, make a contribution of unusual interest in very many directions, and are of great aid to the Geophysical Laboratory itself, concerned as it is with physics and chemistry of the inner earth.

The present organization of the Institution seems, then, not only to contribute toward advance of knowledge in new interlocking or

overlapping areas of research, but to bring back to each of the groups engaged upon special questions a wide range of materials otherwise not readily secured.

In other phases of activity of the Institution the grouping of interdependent researches has been of great significance, in that this type of organization has also facilitated mutual aid between divisions as, for example, in study of problems in Eugenics.

In still another way this plan of organization has furnished means for satisfactory handling of those more sharply individualized projects known as Minor Grants, corresponding to the means of aid for research mainly utilized in the early stages of the Institution's activities. This support was given with expectation that it would either assist the exceptional individual, or advance study of an exceptional problem investigated by students of recognized ability. As the number of these grants increased with passing of the years some researches shifted quite naturally to new aspects of investigation, and the problem of keeping touch with work of this type became increasingly difficult. With a divisional program of administration, large value has been found in the relation of Minor Grant projects to the divisions, thus giving not only the aid of special funds, but with this the support of a group of workers interested in various aspects of the projects undertaken.

The possibilities for assistance through use of the present grouping of activities have been illustrated in the work of Dr. Ernest Anderson, of the University of Arizona, who has coöperated for several years with the Institution through the Division of Plant Biology at its laboratory in Palo Alto. The work of Dr. Anderson in study of the chemistry of tissues in tree growth has related itself to that of Dr. I. W. Bailey, of the Bussey Institution of Harvard University, who has coöperated with the Division of Plant Biology for several years in furtherance of studies on morphology and chemistry of structures involved in tree growth. In another very important relation, the fundamentally critical work of Dr. Bailey on tree growth has been extremely helpful in furnishing through the Division of Plant Biology a biological background for the researches of Dr. A. E. Douglass on changes in the course of tree growth as expressed in tree rings.

Physical Sciences

Carnegie Institution of Washington Year Book No. 34, pp. 12–13, 1935.

In the investigations conducted by Carnegie Institution in the physical sciences, there has been maintained constantly the idea that it is a function of the Institution to devote itself to projects of such magnitude, or of such difficulty in handling, that advance is facilitated through research by an agency free to attack at such a place, or such time, or by such method as seems most desirable. While the work of the Institution has in large part taken form through well-organized and extremely effective departments, such as, Geophysical Laboratory, Department of Terrestrial Magnetism, and Mount Wilson Observatory, a number of the most significant investigations have been conducted by smaller groups, as in the case of the Seismological Laboratory and of investigations in the field of cosmic-ray research.

Although in projects of the Institution in the physical sciences, even where they are set up through the organization of departments, attempt is made to avoid the tendency merely to discuss broad subjects rather than undertake specific investigations, it will be noted that the several fields entered comprise types of research touching a considerable part of the physical universe. This is true in the geographic sense measuring from the center of the earth to the most remote nebulæ, as also in the range from study of structure in the atom in its relation to problems of terrestrial magnetism to discussion of the nature and dimensions of the universe. So it happens that while the Institution does not devote itself directly to the generalized problem of knowledge in the broader educational sense, it is forced by the nature of its researches to include discussion of a considerable part of all phenomena encountered.

Interpretation of Critical Problems in Science

Carnegie Institution of Washington Year Book No. 34, p. 59, 1935.

In an effort to make the results of its researches available to science in general, and to the public, a series of carefully prepared lectures on major researches was initiated by the Carnegie Institution in 1921. Through this program the attempt was made to bring together authoritative statements on major researches of the Institution. While the lectures were frequently arranged in groups representing related subjects, in general each statement was inde-

pendent of the others, and had as its function interpretation of results from a special program of research. The papers presented have in nearly all cases been published, and have been made available to the general reader through magazines, or through the form of releases, or supplementary publications issued by the Institution.

Policy and Program

Carnegie Institution of Washington Year Book No. 35, pp. 1–5, 1936.

Guided as this Institution is by objectives defined in its Articles of Incorporation as "investigation, research, and discovery, and the application of knowledge to the improvement of mankind"; it is necessary to make sure from time to time both that the investigations serving as basis for discovery really represent accurate, fundamental studies, and that the results find adequate application for improvement of mankind. Assuming that ultimate human use is the objective of all activities, it is not difficult for conscientious administration to stress application first, not remembering that importance, and even extent of use, may depend upon quality of the product, as well as upon both understanding and adaptability in application. On the other hand, it would be easy to slip into a groove in the movement of research and fail of relation to the agencies or activities in which the product of investigation is needed.

In examining our situation, a critical question inevitably raises itself concerning the real nature of the field which we occupy. Although in the Institution's activities there has never been hesitation to extend the principle of investigation into any region where search for the truth and organization of verifiable knowledge can be conducted effectively, an evaluation of the contributions made will show that the "research" and its application in which we have engaged fall largely within the field of what is commonly recognized as "science," rather than in other aspects of investigation. This is in contrast to research extended more broadly over what we call human problems. Without suggesting change from existing policies, this may be an appropriate time to consider the relationships to research that have been established, and to examine some of their implications.

In past years the Institution has followed a policy in which flexibility was considered important. Science has been recognized as an attitude of mind representing search for the truth, and also as

organized bodies of knowledge, such as the physical and biological sciences which have been built step by step to stages at which previously unrecognized generalizations or truths became visible. Research, or investigation, has been looked upon as the insistent development of effective means for securing information. The methods of science have been seen as one form of research. Investigation may be conducted in any field where the advance of knowledge or the search for truth is desirable. The methods of approach change according to subject or purpose in view. The investigator may attack problems of mathematics, physics, biology, psychology, economics, or government. Difficulties will vary greatly, as well as possibilities of attainment, but the effort to advance and organize knowledge is essential in each case.

Without attempting to define specific fields of thought in accordance with existing classifications, one may find justification for grouping the contributions of research under three subdivisions: first, the nature of man and his place in the world as we find it; second, the environment of man represented by the natural world; third, the constructive work of man as it tends to build new features or conditions relating especially to his own needs and desires.

A large part of science and research has been devoted to study of our physical and biological environment. In study of man himself we have made reasonable advance so far as morphology, physics, chemistry, and physiology are concerned. To a modest extent we have learned something concerning our psychological activities. There is still a vast range of questions through and around which to work on the general subject of the mind of man.

The study of man as a constructive or creative agent seems only to have begun. So far as this concerns understanding of man's opportunity in relation to the world about him, in relation to his environment of human beings, and in relation to his own interests and desires, we have barely entered the field.

The Institution has thus far limited itself largely to the securing of new data and to organization of information relating to mathematical research, investigation of natural phenomena as expressed either in the world about us or in man, and to history. Work in the natural sciences may have meant only that at given moments the evident fields for harvest in study of nature or of nature in man were large, and new methods opened opportunity for advance. How-

ever, there has been recognition also of a possibility that the next great steps forward might be through study of human problems, with methods as different from those used heretofore as are the present attacks upon natural science, by use of new instruments and new theories, compared with those of ancient times.

In examining the significance of work done by the Institution, and in considering policy for the future, it is important to keep in mind the fact that while our contributions have been largely in the field of science they have often concerned method at least as definitely as subject.

Although devoting itself almost exclusively to the task of searching for new information, organizing it, and making it of record, the Institution has been aware also of the fact that the value of science in terms of its contribution to meet human needs is shown in an almost infinite variety of ways. The relations of physics to engineering, or chemistry to medicine and industries, or biology to medicine, are things which may have immediate human use of easily recognizable and measurable type. Also the value of scientific methods as means for testing of data is seen as of the first order of importance in our struggle to make reality and truth the source of all activities designed to further human betterment.

One phase of the problem of modern science in its relation to civilization under discussion in recent years concerns the ways by which science can be utilized in an effective manner to meet great needs in difficult human relations such as those represented by economics and government. On the one hand there is the view that science is not qualified to deal with those human problems in which the peculiar qualities of mind are factors of primary importance. Another point of view is expressed in the idea that science should extend its field by application of existing and yet to be discovered methods so as to conquer in the fields of economics, sociology, and government.

An intermediate view, which has been followed commonly as policy of the Institution, has involved recognition of the possible aid of science in study of important human questions, but with assumption that the best method of procedure is by a meeting of minds in which the sociologist, economist, or student of government brings into cooperation with him representatives of science whose methods or problems are most nearly allied to his own. It is

certainly to be doubted whether, even if the methods of science are desirable, it is the scientist who should proceed unaided with this application in the fields of economics, sociology, and government.

What might be called practical application of our research results, ranging from the physical and biological sciences to human values, as in psychology, has been the subject of most careful consideration for some years by committees of the Institution. We have endeavored to make sure that the materials secured find their place through examination by experts in the field of application. These studies have been conducted with the hope of bringing to certain applying groups, as in medicine, new materials or points of view which might otherwise remain for a considerable time unused. At the same time the Institution has given careful attention to interpretation of scientific truths such as might aid in forming principles or guiding thought. A beginning has been made also in conference with students from the field of human research with relation to common problems.

Significance of the Technique or Method of Science

Carnegie Institution of Washington Year Book No. 35, pp. 5–7, 1936.

Continuing advance of civilization is made possible as absorption of discoveries and methods of work in each generation helps to form habits of thought in subsequent stages. The real dangers which arise from instinctive action on matters involving logic we assume to be balanced by the possibilities of accelerated action due to accumulated knowledge. The techniques and technologies which arise out of science to become a part of everyday life in industry, or in more distinctly personal activities, may in considerable measure be merely the standardized methods of science developed to a point where they are called arts. Without assuming unanimity of opinion on the subject, there is wide acceptance of the idea that the dangers arising from speeding up of techniques and technologies which lead to development of new activities and industries is at least balanced by development of greater adaptability to new conditions as they arise.

From a number of directions we have the suggestion that for guidance in development of new ideas, and for the protection of society, it is desirable to set up types of organization which may bring together scientists, engineers, and forward-looking students of

social and economic problems with a view to keeping close watch upon related problems in these several fields. The finding of something like common viewpoints for investigators in different subjects may be difficult but it will have increasing importance. Such an activity might be established in the hope of fitting new ideas and new techniques to advancing industries and to new phases of social and economic endeavor. If developed guardedly, such a forward-looking program presumably would not hinder the advance of civilization, and might be expected to aid in adjustment of human groups to some of the changes which inevitably take place.

It is important to note that responsibility for keeping in view the possibility of social influences arising from use of scientific techniques rests in part upon the scientist. Assuming that there will be an uneven movement in the economic-social stream, there is value in having those best acquainted with the nature and possibilities of new materials and new activities keep in mind the fact that they, as the source of such influences, should have some acquaintance with ultimate application of their products. At the same time it must be realized that unwise use may be due to factors of social significance with which the student of social problems should plan to keep close acquaintance.

In following the implications of these questions it is important to examine the idea that scientific methods may function as techniques which in various ways influence modes of thought and even concern aspects of judgment. If science exerts this influence, it is essential that its contribution be guarded with the greatest care as to use in education, and also watched by the ablest students as to the manner in which it may affect or guide thought. As one possible influence of science upon thought, we may assume that if the minds of all citizens could be so informed and trained that, as a rule, there would be insistence upon having and using the elements of fact and reality, which are the basis of science and research, there would be guaranteed a relatively safer situation with reference to the handling of all human problems than has commonly obtained.

International Influence of Science

Carnegie Institution of Washington Year Book No. 35, pp. 7–9, 1936.

Even in the broader relations of society which concern affairs of nations and peoples, one may recognize the method of the scientist

and the investigator as having a significant influence. As contrasted with economics and government, the relations of culture, and art in the broader sense, may have a larger element of mutual human interest. For this reason international culture is seen as one of the factors drawing together peoples which at any given moment may have widely differing economic and political ideas.

In a measure, comparable to what develops out of cultural contacts, science often represents vital interests of peoples of such a nature that results obtained have a high degree of mutual value. Science has both cultural and economic values, but in relations between peoples the cultural influence may be relatively important.

Added to other features of significance in the bearing of science upon international relations, it is important to note that for a great number of scientific problems the solutions can be obtained only by cooperation of nations, or perhaps by the peoples of the whole world. So in activities of this Institution, specifically in researches of the Department of Terrestrial Magnetism, many of the problems require cooperation of investigators over the entire world for securing of observational data, while the results find instant use in every part of the globe. In another direction, studies concerning oceanography and certain aspects of marine biology can be advanced only through international cooperation, and the results are of immediate use in many countries. The researches of Dr. V. Bjerknes, in Norway, conducted with the cooperation of the Carnegie Institution, in the field of fundamental physical-mathematical studies relating to the atmosphere, have contributed to the advance of meteorology in every country of the world. Investigations by the Geophysical Laboratory on the nature of the earth, and with particular reference to volcanic phenomena, have needed the results of studies in the United States, Japan, East Indies, Africa, Europe, and South America. At all times there has been the utmost of cooperation from all countries which have been touched, and the results have become available for the peoples of these regions.

It is interesting to observe that among the nations of the world at the present time the contributions of science and culture have tended to bring together, and hold together, some of those units which have relatively small power in the sense of international control, but in which the cultural and scientific influences have

certainly furnished guidance of exceptional significance for the world.

Science and the Unity of Our Environment

Carnegie Institution of Washington Year Book No. 35, pp. 9–13, 1936.

Assuming that the major contributions to science and research made by the Institution relate to man's environment, along with his physical structure and functioning, rather than to man in the strictly human sense, or to his creative work, it is important to note that investigation of our environment is largely of the analytical type. But there is another feature of the problem which requires attention, and for which the need is not less than for other kinds of investigation. This is the examination of our surroundings in the sense of their unity or their synthetic value.

The universe in which we find ourselves is the product of what seem to us practically infinite ages of creative activity, building the earth, shaping it to the present configuration, and peopling it with a vast range of life. In this world the elements have been adjusted to each other through eons of give and take and evolution, until a tremendous complex faces us with its parts well fitted together. Man grew up in this environment, being in fact a part of it and a growth out of it. His whole being has been attuned to it physically, intellectually, and spiritually.

Man with his creative mind proceeded then to develop that type of organized effort which made beginnings of common culture possible and also, in the social sense, heritable. Groups of men extending their activities through society began here a battle with their surroundings. Suspicion of the shadowy forest and fear of the torrent gave place to contempt as man saw himself becoming master. And soon he was not merely conqueror but a destroyer. Forests fell in his march. Living creatures became vassal, or fugitive, or they vanished. In joy of use, man's creative work produced a new world, in which much of what remained was ordered to suit his needs or to please his fancy. The values of adjustment and interplay in nature, established through ages of growth and evolution, were no longer in balance, for, in part, man's will had been substituted for this balance. Much from the original elements of nature

remained, but the unity and the synthetic factors were changed. The resources of nature upon which man is dependent continued in considerable part as separate elements, but the organization was disrupted, and many of the values were lost.

In recent decades mankind has raised question as to what it is that has been lost, but the answer can be given only in terms of original materials and of conditions now largely destroyed. Only in part has science mastered the problem of the organized natural world as resulting from the creative process. To a still less extent did the agencies concerned in destructive processes learn to know what it was they destroyed.

We have come now to learn that a forest is not just board feet per acre, but consists of all the elements in life from the most insignificant to the greatest, and if it is to be replaced it must be on the basis of all values concerned; so it is with the whole natural world.

In discussing the functions of research and science as they concern man with reference to his being, his constructive activities, his relations with his surroundings natural and human, it is desirable to note that the physico-biological environment is not just atoms, rocks, chromosomes, plants, and animals. It is also the picture of these things composed by nature in the millions of years during which the perspective of space, and time, and color, and movement, and growth was being defined. Perhaps what we call beauty in it all is partly an expression of inheritance in a mind so long accustomed to these values that they seem inherent in thought.

Research on this phase of nature so far as it concerns individual natural resources calls attention to the possibility that many values not now appreciated, but to be needed later, are perhaps in process of extinction. Not until we have come to know all of our present and future needs and all that is in nature, with the relation between these elements, should we permit anything to disappear, or allow the types of adjustment attained in nature to be dislocated. Examination of any part of the world that has passed through the development of intensive civilization shows the modifying influence of man upon the face of nature.

The progress in America through recent decades of what we call conservation, and for the world as a whole through centuries, has concerned itself with preservation and best use of our inheritance

in nature. Conservation and replacement of forests still remains one of our most interesting and important problems, partly by reason of the fact that the forest is in general still an element of wild nature in the process of domestication and utilization. The vigorous discussion of conservation problems in other lands, and in our own country at the moment, expresses in various ways the values involved in this question. The fundamental elements are worthy of the most intensive study as to their scientific meaning, and ultimately in terms of their human significance.

To some extent the Institution has concerned itself with research on the environment as here considered. Studies of Dr. R. W. Chaney upon the history of environments, physical and biological, in the western part of America and in Asia make a contribution to biology and history of much importance. The work of Dr. F. E. Clements on the ecological problem in America has made many new paths which future investigators and appliers must follow. Activities of the Division of Plant Biology, concerned at the same time with study of hereditary factors in plants and with the relation of plants to their environment, furnish a safe foundation on which to build. And this program is advanced by cooperation with leading investigators throughout the world.

A problem of limited scope has been examined recently in the study of a small area on the coast of California containing the only existing remnant of a primitive Monterey cypress forest with its associated plants and animals. The research has given opportunity for examination of a question of this type from the point of view of all sciences concerned, and with consideration also of human use extending out even to the securing of expert knowledge on scientific values as they touch the field of æsthetic appreciation. The cooperation of the Carnegie Corporation of New York in furtherance of this study at Point Lobos has made feasible the conduct of an investigation which will have lasting influence in the study of man's relation to his environment.

Elihu Root

Carnegie Institution of Washington Year Book No. 36, pp. 1–5, 1937.

One of the most effective means for estimating the importance of Elihu Root to the Carnegie Institution is found in noting the extent of his influence upon policies and activities during those later years

in which it was no longer possible for him to attend meetings of the Board and Executive Committee. At no time during this period of his absence from the administrative offices or from the council room was any major question discussed without reference to policies or opinions representing Mr. Root's point of view. So, it has come about that with the passing of Elihu Root, on the seventh of February, 1937, a relation which had obtained since the founding of the Institution in 1902 continued as an established influence upon the objectives and policies of the Institution.

At the time of his separation from us, Mr. Root was the only surviving member of the original Board of Trustees, and was the only person fully acquainted with the ideals and purposes expressed by Mr. Carnegie in founding the Institution. In his relation to the administration Mr. Root served as a member of the Executive Committee from 1902, as Vice-Chairman of the Board from 1903 to 1912, and as Chairman from 1913 to 1937. These contacts gave him complete acquaintance with the administrative and scientific activities from the beginning. Through this touch with the program he had full appreciation of factors which had made it important on one hand to maintain those activities and objectives, the soundness of which time and experience had tested, or, on the other side, to recognize the elements which might be allowed to follow well-defined lines of evolution toward fields quite different from those originally visualized.

The fact that Mr. Root had full knowledge of ideals, objectives, policies, administration, effective progress in fundamental research, and concerning the meaning of the Institution in terms of public relations may not be considered as due alone to long and close touch with the program of work. The high qualities of intellect and interest, coupled with broad vision and ability to determine the essential elements of complicated situations, which distinguished him as the foremost citizen of America, made it possible for Mr. Root to evaluate the objectives, organization, and accomplishments of the Institution. His vision over the whole field of the Institution's work, past and present, was so clear, and his appreciation of human questions involved so unusual, that discussion of any problem brought help to the Board and to the Administration.

Mr. Root's interest in and understanding of what might be accomplished through any field of research was always an excep-

tional stimulus to investigators and to the Administration, and yet this influence was exerted without the danger of becoming lost in details or of failure to recognize that careful research is the method by which fundamental truths are discovered and verified.

In conducting business of the Institution, whether concerning matters of finance, organization, outside relationships, or plans for a research, Mr. Root's thought was always direct, and his judgments determined by uncompromising adherence to principles which human experience had shown to be the most reliable. Were it not that this was known to be his established method of procedure, one might have been inclined to think that in treatment of problems concerning the search for scientific truth, the unvarying acceptance of realities and what they imply as seen in science had come to have an influence on research administration. Actually the conditions described were those under which administration of research was itself held to consistent support of precision and truth, whether in financial arrangements, organization, or in the methods by which investigations were advanced.

In development of the many fields of activity represented within the Institution, Mr. Root's interest was always keen, whether the problem concerned atomic physics, geologic time, the significance of chromosomes or genes, historical research, or certain of those fields of investigation in which science and the humanities may combine to mutual advantage. Mr. Root was an ardent supporter of the idea that the Carnegie Institution should be so organized as to permit mutual aid among the projects or departments, as well as between the groups of the Institution and other comparable agencies. In some measure progress of certain Institution researches in recent years has been made possible through his support of this view.

Following the principle concerning importance of quality in personnel advocated by Mr. Carnegie, Mr. Root gave his support consistently to selection of the best type of man, as also to what seemed the most significant type of problem. At the same time he supported the view that good men and good problems must have good organization and good environment, both mechanical and human, if the highest success is to be attained.

Although insistent in support of the idea that institutions devoted to research have a primary responsibility for advancement of knowledge, Mr. Root maintained also the importance of recognizing

responsibility on the part of the Institution for making the results of its investigations available in easily interpretable form for use by the world of science, by engineering, for general application, and for understanding by the people. It was his view that the continuing advance of science depends in considerable measure upon offering to the public opportunity to educate itself with reference to the accomplishments of research regarding the fundamental nature of the world of things about us, as well as of man himself.

In his later years, Mr. Root often referred to the fact that among the problems which seem to have increasing importance, one of the most significant concerns the need for making sure that the fundamental elements derived from major scientific advances are so interpreted and presented that they may become embedded in the thought of the people. Without such handling of the materials of science Mr. Root considered that the rate of progress might be slow and the advance of civilization perhaps impeded.

The attitude of Mr. Root toward interpretation of results of research is well illustrated by comment which he made some years ago at the end of an Executive Committee meeting devoted to discussion of administrative detail. Having finished the work which required a vote of the Executive Committee, Mr. Root drew back his chair and said, "We will now consider matters which represent more fundamental responsibilities of the Institution," and for a half hour discussed the desirability of making the public acquainted with some of the most interesting and fundamental discoveries in study of the spiral nebulæ, ending with the comment, "If such things could be interpreted to the public in simple form, it would be worth half of the total expenditure of the Institution." He gave his enthusiastic support to the attempt to plan carefully prepared public lectures, conferences, and exhibits, and on one occasion remarked with particular reference to functions of a proposed addition to the Administration Building for use in public relations, "You will be carrying out some of the purposes of the Institution in which Mr. Carnegie was especially interested."

While, then, we miss the immediate companionship, support, and stimulus of the man who through this long period has helped faithfully and effectively to carry out the purposes which led Mr. Carnegie to found the Institution, we may yet say that his influence

will continue to be felt, and his voice to be heard, through the coming years however far they may stretch.

Science and Social Problems

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In the search for interpretation of certain characteristic present-day conditions, investigational activities of recent years have placed such emphasis upon the relation of science to the processes of social evolution that a considerable literature on the subject has developed. In spite of the many suggestions made, there is probably general agreement with the idea that the influence of science upon society is not in any sense comparable to the kind of effect produced by purely physical laws. The farther we advance in consideration of the problem, the clearer it is that the answer will be obtained only after we have a clear understanding of the content and mode of development in science, of the structure and mode of evolution of society, of the manner in which new facts presented by science are absorbed, and of the way in which the methods of science are adapted to processes of human thought.

It is necessary that within the field of science we know the degree of complexity of organization and classification of subjects. It is equally important that in society we not merely have appreciation of the difficulties in interpretation of the influence of science, but that we attain a degree of awareness of interdependence among social elements comparable to our understanding of the interrelation among elements involved in the unity of nature.

In advance of science, just as in affairs of everyday life, attainment of success involves that balance of judgment which brings to bear both knowledge of details and the kind of vision which gives perspective comprising the factors involved. Even infinite patience in gathering details may lead only to accumulation of multitudes of facts the possession of which will have little significance. So, looking in the other direction, construction of elaborate classification schemes and formulation of comprehensive theories may have small value in absence of intimate acquaintance with basic details.

We consider that science is advanced when a previously unknown fact or a new item of information is located and described. Subsequent history may show that the utilization of the fact with relation

to other knowledge, or its application for the benefit of mankind, may be delayed to a period far beyond the time in which the greatest emphasis is placed upon the discovery. When, at some later day, the item of knowledge is put in its place with relation to other materials, this useful contribution may be considered greater than that represented by the original discovery.

The formulation of great hypotheses, or of theories, or of points of view concerning interrelation of elements in the field of knowledge may be seen as something of exceptional importance in the advance of science or of civilization. But often we place larger emphasis on mere discovery of isolated elements. Again, we give high measure of approbation to utilization of new information, either through isolated facts or as representing points of view, when applied in such manner as to better the position of human kind with reference to maintenance of life, to advancement of individual interests, or to appreciation and enjoyment of values in living. In the forward march of science and civilization we seem to pass through periods in which we are concerned with intensive delving for facts or materials or items considered important in themselves. At other times we direct attention toward organization of these materials into patterns of special human significance.

Periods of exceptional stress, such as the Great War, or the recent depression, tend to emphasize reorganization of materials in such manner as to contribute the maximum toward betterment of the situation for mankind. In the middle and late stages of the recent depression large contribution has been made in this country toward reorganization of knowledge, formulation of new views, and establishment of new institutions in the interest of human betterment. Though science has been drawn upon largely to aid in working out these plans for reorganization, seemingly one of the greatest difficulties has concerned attainment of proper balance between details involved and the theoretical conception, or between the conception and its human application. Perhaps the lessons taught by this experience will help to point the way toward better appreciation of balance in organization involving both science and the various forms of its application.

The much-desired cooperation between students of human affairs through joint effort of workers in the fields of the natural and social sciences, economics, government, and philosophy has seemed less

easy of realization than was perhaps expected. There can be no doubt that certain of the attitudes and methods of science appear difficult to use in application to human relations, and that the methods applied so directly in the natural sciences often seem inadequate in research upon our vastly complicated human questions. There are, however, many aspects of research procedure developed in the natural sciences which will have increasing value in application, either directly or indirectly, through various phases of the social sciences.

There is importance in the idea that while in certain aspects of natural science, as in physics and chemistry, one seems to deal with immutable or fixed laws, the factors presented for consideration in social science broadly or in economics shift so readily that the methods of natural science can be applied only with difficulty. It is, however, well to remember that problems in biology also show us a situation in which changing conditions, and apparently changing factors, present one of the recognized features in any investigation. The larger history of evolution in life-forms gives one of the best illustrations of continuous change, and yet these changes seem to depend upon fundamental laws which may continue in operation much as in physics or chemistry while new factors come and others go. The general principle of evolution rests upon the idea of conserving certain features which might be called fundamental, and the continuous shift in others, leading to production of new situations or features which may be recognized as creation.

In the rapid shift of human affairs, conditions, opportunities, and obligations change so rapidly that we may tend to the view that the laws of conduct themselves have changed fundamentally. So we seem almost to find in international diplomacy a new statement of human obligations, and a new interpretation of principles which have had general recognition among individuals over the world. And yet, we may have faith that things which are recognized as representing the principles of right and honesty will in the end prevail. Perhaps neglect to recognize this point of view is responsible for some of the difficulty in the world at the present time.

It is also to be borne in mind that we must not only recognize the principle of change or evolution in whatever relates to life, but we must give recognition to the principle of constructive or creative activity developing in the peculiar types of creatures known as

human beings. But creative activity does not rest upon a breaking down of law. It is a natural expression of certain laws through means which make evolution and the development of new elements possible.

Orderly movement in social evolution probably depends in considerable measure upon our ability to determine the balance which should obtain among some things which are of the nature of immutable laws, others which we find leading to evolutionary development, and still other features in human life which have to do with constructive or creative activity. This may be one of the great questions for the future.

One aspect of this problem, which is probably often misunderstood, has to do with the influence of science upon society in the sense of utilization of facts merely as facts, and not as parts of a wider scheme of knowledge. It is possible to bring extreme confusion into human affairs through the use of facts. This may be illustrated when on two sides of a legal case opposing talent uses scientific information, but in each case covering only a part of the evidence. Facts are used, but not all of the facts, and such situations make controversy possible. It has been said that truth differs from fact in that truth represents all of the facts, or, as is said commonly, all of the truth, so set up as to give a clear picture of what exists. It has also been said that honesty is the expression of fact or of the truth as involved in discussion of human relations.

Science and Appreciation of Nature

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One illustration of a way in which science has been held to affect present-day thought is found in the suggestion that research has tended to diminish the interest of mankind in the vast world of nature about us. This is in spite of the fact that we are practically embedded in nature, and that much of man's philosophy of life in past centuries has based itself upon observations concerning the character of the world in which we live and our relation to it.

The argument in favor of the view that there is diminishing interest in nature on the part of modern man rests in considerable part upon the idea that present-day tendencies look toward shifting of appreciation to results of mechanization in the world, and to some extent in the life of man, by reason of advances of science. It

has been thought that jazz, the radio, the automobile, and many other contributions of present-day thinking have turned interest away from the elements of nature and that, considered broadly, mankind of today transfers its attention to the varied, and often mechanized, activities of man, rather than toward the tremendous range of evidences of creation in the world about us.

If it be true that the coming of science has diminished interest and value found in nature, serious harm has been done. Much of our reverence and religion of the past had its origin in what we know of the still incomprehensible world of nature, and much of the soothing influence exerted upon man through his environment has been derived in some measure from the appeal of the natural world and love of its beauty. It is, therefore, a matter of importance to consider whether the influence of science in this respect is really detrimental.

Whatever argument is presented on one side or another of this question will almost inevitably become complicated, but it is important at the moment to call attention to the fact that with the extension of our knowledge of the universe through science in all directions, by the telescope into the infinite spaces inhabited by spiral nebulæ, by the microscope into the infinite littlenesses of the world of bacteria and molecules, or by the student of history through the vast reaches of time, we have come to see the world as almost infinitely complicated, and yet having all of its parts intimately related. Therefore we think with some assurance on the idea of unity of nature. At the same time we have seen the movement of the world through time develop that aspect of being which we call evolution, producing further developments, not only more complicated, but which we consider more advanced than those of preceding ages. So, seen in the light of the broader reach of science, the world about us becomes more complex and more wonderful, and yet more dependable, more clearly creative, and more beautiful. And question may well be raised whether the influence of science through interpretation of the world in which we live does not tend to advance or develop our interest in or appreciation of nature more rapidly than the elements of mechanization tend in the other direction to turn our attention away from nature and largely to the present-day works of man.

Relation between Research and Organization of Knowledge

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In founding the Carnegie Institution an agency was set up in which the purposes were deliberately so defined as to present a set of objectives quite different from those of well known types of organization. And with this action there arose need for intensive study of the opportunity by all selected officers and those concerned with success of the project. The general purposes of the Institution as an agency devoted to "investigation, research, and discovery, and the application of knowledge to the improvement of mankind," as defined by the Founder, conveyed an idea of the objectives in a form intelligible to all. But, just as in institutions devoted to higher education there was much discussion as to means by which the defined goals might be attained, so here, there has been natural and proper consideration of means by which ideals of this Institution could be realized.

Research of the constructive or creative or inventive type covers a vast range of subjects and can be conducted in a great variety of ways. Application of the results "to the improvement of mankind" can be viewed again as presenting a multitude of possibilities. To those who organized the beginnings of this great work the opportunities seemed almost limitless. Most wisely they safeguarded the program by insisting upon several principles which were evidently in the mind of the Founder. One of these concerned *quality* of projects, of persons involved, and of materials made available for programs or projects; a second general requirement expressed the need of striving for attainment of what is *fundamental* as, over the years, the best means of advancing knowledge. With reference to application of results, the statement regarding "improvement of mankind" seemed clearly to envisage a process of advancing development of mankind, in which work of the Institution would be contributing to those more fundamental aspects of life out of which improvement grows or is built. So, among his last utterances on these subjects, Elihu Root voiced the hope for such continuing absorption of the results in advance of knowledge into the thought of the people as would permit building to higher and higher levels of thought, appreciation, and belief.

Among the problems necessarily involved in the program of an institution of this nature, one of the most fundamental concerns the

relation between that form of intensive investigational activity commonly thought of as representing research, and the type of constructive activity known as organization of knowledge. We know well the contributions of constructive or creative work reaching into fields of the unknown and making new materials available. Organization of knowledge is recognized as opening visions of the whole field, and sometimes leading to such glimpsing of relations between areas of knowledge as makes possible the formulation of great generalizations or principles. The first activity has been recognized as contributing enormously to advancement of knowledge; the second is seen to give acquaintance with relationships or principles which are among the most important values in knowledge.

Depending upon the importance of factors having special significance at a given time, knowledge may seem to be advancing either by reason of particular intensive researches, or because of emphasis on newly developed organization of information. Unless the whole field of learning be examined with reference to all of the types of creative work, it would be easy for difference of opinion to develop concerning the activities through which the more important advances are made.

From one point of view, it would be possible to indicate that the degree of intensiveness of research in limited fields determines the rate of progress. If this were true, it might be desirable to organize investigational programs in such a manner that emphasis would be placed mainly on concentrated attack upon limited problems, in the hope that through such effort the whole range of knowledge would, in time, be furthered most effectively.

On the other hand, argument might be made that unless the results coming out of intensive research are related to comparable materials from other fields a very large part of all that could be known through the interlocking of contributions might never appear. Argument might also be made in favor of the view that it is the clear vision of knowledge organized with reference to particular problems that gives us the principles which become the foundations upon which research is built. So, in the field of biology, the general law of evolution is a type of idea which has given tremendous stimulus to study of life in practically every realm. Or, in the inanimate world, the law of gravitation is a foundation upon which much of research on the visible universe must stand.

Experience in many kinds of institutions concerned with research, and with knowledge broadly, indicates that the most effective organization, and the most economical scheme of operation, is one in which there is careful balance between activities devoted to intensive or concentrated research and those giving vision over larger areas, covered in such manner as to obtain the major generalizations coming out of special activities, as also the largest values from the individual researches.

It is true that the term "proper balance" will necessarily be defined according to conditions at a particular period or place. And as these conditions vary the emphasis on different parts of the system will be modified to advantage. It is also true that the question of balance, and in some ways of the wider and deeper perspective involved, has greatest significance in connection with institutions which represent a considerable variety of subjects.

Realizing that the significance of perspective is most clearly appreciated where the spread of subjects or activities is wide, it is important to keep in mind the fact that in the areas of research covered by the Carnegie Institution of Washington the range of interests extends from the most intimate details of atomic physics out through chemistry, biology, and history up to the threshold of investigations directed more particularly at inquiry concerning human life and activities.

It is interesting to note in this connection that at various times in the history of science, and of philosophy, and also of religion, there have developed definite expressions of the idea of unity, including everything in the physical and biological universe, not only in space but through time. As knowledge advances, this idea of unity becomes in the scientific sense an increasingly practical feature of research on the organization of knowledge. It is no longer possible to study the broader problems of astronomy and the universe without recognition of an interrelation among the elements of the world about us wherever we touch them. In the same manner it is discovered that study of events in geological history, even for remote periods, is based upon application of principles which extend through time, and may be carefully examined in the world today. Again in consideration of the problem of development of life or evolution, investigation of the various stages in the process is based upon the idea of growth through the years in materials which

have a continuity and are, so far as we know, affected in comparable ways by influences through space and time.

In attempting to reach an adequate understanding of relations between widely separated types of researches it invariably becomes important to have each and all of the problems involved stated in such manner that the essential elements are intelligible to investigators interested in determining the connection or relation among these various aspects of nature. Results from the most intensive research will commonly and naturally be expressed in terms of formulæ and shorthand methods, developed in order to permit the investigators to work rapidly and exactly, without the limitations imposed by long and perhaps complicated statements or explanations. Frequently these formulæ are not understood by investigators in other fields, and it becomes important to find some means by which the essential elements of the contributions can be made available to others.

There is much difference of opinion as to how interpretation of basic scientific data may best proceed. Sometimes it is accomplished by what may be called a matter-of-fact statement, which gives details that can be defended from the point of view of the investigator, but which has no vital meaning to students of other problems or of human interests widely. Sometimes it is possible to look into deep reaches of a particular field and appear to visualize the materials represented, but in many cases the result has no greater significance in terms of intellectual progress than the impact of light rays picturing a particular landscape on the retina of an ox. There must be some conscious relation of the elements represented to each other, or in the sense of research and knowledge nothing happens.

In the case of phenomena such as those of the Grand Canyon observers may look into the depths of the great gulf, with its rugged and spectacular walls, and of fifty persons receiving the same picture on the retina only one or two may have a sense of understanding of what it means. Another person may come who fits the various elements together and who brings out of his experience the beauties of color and form, the grandeur of height and of mass, and with this the sublimity of power and of changes in the past which have produced these effects, and at the same time have recorded the lapse of ages constituting one of the most important elements of the picture.

As yet we have made only too little progress in the attempt to find the best way to interpret the facts of science so as to make them intelligible, not merely to the public, but to investigators in other fields of research as well. In reality this constitutes one of the major problems involved in consideration of the future of science and of knowledge.

Granted that we become expert in the simple and clear interpretation of data in the various fields of research, it becomes possible then to bring the pictures of these aspects of research together, and to form opinions concerning their relation to one another; thus bringing about relation of materials which may furnish the foundations for generalizations; the generalizations in their turn contributing toward interpretation of details in other fields.

So there is reason to believe that in any scheme by which we attempt to secure the fullest values through research, and from the organization of knowledge, we will be dependent to a considerable extent upon our ability to interpret the details in such form that they may be fitted into the general setting, and thus help to advance those generalizations which may become fundamental principles of science.

As the program develops, it becomes increasingly clear that one function of the Carnegie Institution lies in making possible such relation of our various types of specialized research to one another as will bring largest values for each research, and will also facilitate building upward in the broader scheme of knowledge. This process will depend in some measure upon acceptance of the idea that all elements of nature, and of knowledge, have interrelationships. We now realize that no science can exist alone; no branch of knowledge can exist alone; all must be related to other knowledge if they are to attain their largest value.

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